Soil Texture Aanalysis by Laser Diffraction – Standardisation Needed

How widespread and important is: 1) Under reporting of pretreatment method, 2) Uncertainty caused by small sample size, 3) Need for translation of old PTF's based on sieving and sedimentation methods, 4) Lack of awareness in literature?

Callesen, Ingeborg; Palviainen, Marjo; Kjoenaas, O. Janne; Armolaitis, Kestutis; Rasmussen, Charlotte

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wageningen soil conference
SOIL SCIENCE IN A CHANGING WORLD

WAGENINGEN
UNIVERSITY & RESEARCH

Soil Science in a Changing World

EDITORS
J. Wallinga
G. Mol
V.L. Mulder
A.M. Zaal
B. Jansen

27–31 AUGUST
2017

PROGRAMME AND ABSTRACT BOOK

Book of Abstracts

Wageningen Soil Conference 2017

'Soil Science in a Changing World'

Editors:
J. Wallinga
G. Mol
V.L. Mulder
A.M. Zaal
B. Jansen

27 - 31 August 2017
Wageningen
The Netherlands

Wageningen Soil Conference 2017
'Soil Science in a Changing World'
27 - 31 August 2017
Wageningen
The Netherlands

Editors: Jakob Wallinga[1], Gerben Mol[1], Titia Mulder[1], Anne Zaal[1], Boris Jansen[2]

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Contents

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  International Plant Nutrition Institute, Kenya

Welcome

Welcome

I firmly believe that soil scientists should take a leading role in achieving some of the Sustainable Development Goals. We can provide unrivalled insights in processes and interactions occurring at the earth surface, which are crucial to e.g. climate change and food security challenges. I'm profoundly looking forward to discuss with you and other participants how our community can contribute to solving the global challenges of our time.
Personally, I have warm memories of the previous meeting in 2015, where we agreed on a resolution which I would like to repeat here:

Participants of WSC2015 – Soil Science in a changing world agree *that*:

- Soils play a key role in confronting challenges related to food security, water resources, climate change and biodiversity.
- Increasing soil organic carbon will generally enhance soil life and promote soil functioning with respect to the challenges listed above.
- A professional communication strategy is needed to ensure that society benefits from soil-based solutions.

And therefore agree *to*:

- Urgently identify actions for soil-based solutions towards achieving United Nations Sustainable Development Goals.
- Initiate and strongly support programs that aim at a lasting increase in soil organic carbon.
- Develop convincing narratives on soil-based solutions, and communicate these with stakeholders and policy makers.

WSC2017 provides an excellent opportunity to remind ourselves what we agreed upon, discuss new insights and developments in soil science and discuss what actions are needed to ensure that we, as a community, contribute to realizing the Sustainable Development Goals. Together, we will make it again an inspiring and fruitful event.

Jakob Wallinga
Chair Wageningen Soil Conference 2017

Organising committee


Boris Jansen


Gerben Mol


Titia Mulder


Anne Zaal

Programme

Programme

Sunday, August 27th 2017

18.00 – 19.00 *Icebreaker, drinks & bites and Pre-registration - Café Loburg (Molenstraat 6, 6701 DM Wageningen)*

Monday, August 28th 2017

08.00 Arrival / registration – *Lobby, Orion Building (Bronland 1, Building 103, 6708 WH Wageningen)*
Poster Placement, Coffee

08.30 – 08.45 **OPENING SESSION** – *Plenary meeting room (Orion 1040)*
Welcome *– Jakob Wallinga, Wageningen University & Research, Chair Wageningen Soil Conference*
Opening address *– Bram de Vos, Wageningen University and Research, Managing Director Environmental Sciences Group*

THEME 1: Governance and Policy
Chair: Margot de Cleen

08.45 - 09.10 **KEYNOTE** – *Plenary meeting room (Orion 1040)*
Annette Schneegans, European Commission, Belgium
Soils in the EU – Agricultural Policy and research working in tandem to spur innovation

9:10 – 9:35 **KEYNOTE** – *Plenary meeting room (Orion 1040)*
Simon Moolenaar, Commonland, The Netherlands
Landscape Restoration for Sustainable Development: a holistic business approach

09.35 - 10.00 Plenary discussion - *(Orion 1040)*

10.00 – 10.15 One minute poster pitches Governance and Policy – *(Orion 1040)*

Presented posters:

Sandra Boekhold: Inspiration: the implementation of a strategic research agenda for spatial planning, land use and soil systems management

Lilian O'Sullivan: Functional land management: EU and Brazil intercontinental learning – a comparison of the scales of action and actors in landscape management

Michiel Rutgers: Soil services in the Atlas Natural Capital of The Netherlands

Vaclav Voltr: Study of erosion control measures in the Czech Republic

10.15 – 10:45 Poster sessions with coffee break and snack – *Restaurant 'The Spot', Orion building*

10.45 – 12.15 **PARALLEL SESSIONS**

2 sessions with 6 oral presentations

	Session Governance & Policy 1 ***(Orion 1040)*** *Chair: Simon Moolenaar*	**Session Climate change 1** ***(Orion 2051)*** *Chair: Karen Vancampenhout*
10.45 – 11.00	*Kirstin Marx* SOILAssist – Assisting farmers to reach the SDG goals 12 and 15	*Diego Abalos* Understanding the relationship between plant traits and nitrous oxide emissions from grasslands soils
11.00 – 11.15	*Ruud van Uffelen* Smart topsoil relocation to mitigate land take impact on soil resources	*Madhav P. Thakur* Climate Warming and Soil Biodiversity: How and When Trophic Interactions Matter!
11.15 – 11.30	*Fernanda Ayaviri Matuk* Ethnoecological knowledge exchange and participatory land use planning: The case of SISA policy in the Amazon Kaxinawa Nova Olinda Indigenous land	*Mansour Ahmadi Foroushani* Impact on terrestrial exposures from dust elements and dust event frequency
11.30 – 11.45	*Francesca Bampa* Land and soil management: structuring empirical knowledge about soil functions using multi criteria decision analysis	*Vincent Logah* Soil carbon and nitrogen stocks of forest islands of West Africa
11.45 – 12.00	*Dina Popluga* Approach to the assessment of land use optimisation within the context of climate policies of Latvia	*Murray Moinester* Sequestration of atmospheric carbon dioxide as inorganic carbon in the unsaturated zone under semi-arid forests
12.00 – 12.15	*Hedwig van Delden* Integrated assessment modelling for preventing and mitigating soil threats: the role of European policies, land use and land management	*Ingeborg Callesen* TransparC: Forest soil carbon simulation model

12.15 – 13.30 Lunch & Poster sessions – *Restaurant 'The Spot', Orion building*

THEME 2: CLIMATE CHANGE

Chair: Pete Smith

13.30 – 13.55 **KEYNOTE** – *Plenary meeting room (Orion 1040)*
Daniel Richter Duke University, United States of America
Earth's soil from the critical zone perspective

13.55 – 14.20 **KEYNOTE** – *Plenary meeting room (Orion 1040)*
Karen Vancampenhout, University of Leuven, Belgium
The ways of the dead: ecosystems handle their organic matter differently

14.20 – 14.45 Plenary discussion - *(Orion 1040)*

14.45 – 15.15 One minute poster pitches Climate Change – *Plenary meeting room (Orion 1040)*

Presented posters:

Hyeoun-Suk Cho: The changes of carbon amount of soil and rice plant by kinds of different green manure crops

Zita Kriauciuniene: Adoption of spring oilseed rape sowing time and soil tillage technology in changing climate conditions

Vincent Logah: Biogeochemistry of old Anogeissus Groves in the Mole National Park of Ghana

Eduardo Mendonca: Stabilized nitrogen fertilizers and the emission of CO_2-C of a tropical soil

Ikabongo Mukumbuta: Effect of composted manure application on greenhouse gas intensities and soil carbon in cornfield: a 3-year field study in an andosol soil

Mirjam Muñoz-Rojas: Photodegradation processes in drylands: case studies in South Europe and Western Australia

Myung-Chul Seo: The periodical changes of soil carbon according to morphological characteristics with several kinds of organic material

Sofia Sushko: Chernozems CO_2 emission vs. soil microbial respirstion

Maricke van Leeuwen: The role of soil variation in nutrient balance modelling on dairy farms

15.15 – 15.45 Poster sessions with coffee break and snack – Restaurant 'The Spot', Orion building

15.45 – 17.15 **PARALLEL SESSIONS**

2 sessions with 6 oral presentations

Session: Sustainable Development Goals *(Orion 1040)*
Chair: Margot de Cleen

Land Degradation Neutrality (LDN): ambition and operational aspects for stakeholders

This SDG session aims to identify instruments and indicators that are meaningful for reaching the SDG 15.3 and that are fit for practical use by you as stakeholders.

Wageningen Environmental Research wants to publish a discussion paper about ambition of LDN 15.3 and give direction to how this can be done in practice (presentation: Saskia Keesstra).

Session Climate change 2 *(Orion 2051)*
Chair: Daniel Richter

15:45-16.00: *Marta Dondini*
Modelling soil organic carbon following sand-use change to Brazilian sugarcane

16.00 – 16.15: *Putri Oktariani Rianto*
Effect of manure and fertilizer application on belowground carbon component and carbon emission in corn field

16.15 – 16.30: *Rika Ratna Sari*
Do cacao agroforest maintain soil carbon stock?

16.30 – 16.45: *Tatiana Rittl*
Sensitivity of soil organic matter decomposition of biochar-amended soil to warming

16.45 – 17.00: *Titia Mulder*
Soil carbon assessment for climate change mitigation in The Netherlands

17.00 – 17.15: *Gerard Heuvelink*
Towards a sampling design for monitoring global soil organic carbon stocks

17.15 – 18.15 Drinks & snacks & poster sessions – *Restaurant 'The Spot', Orion building*

Tuesday, August 29th 2017

Excursions and Side Events, with various options.

At 19.00 hours the Conference dinner starts at Restaurant H41.
We offer an buffet style dinner with drinks, dessert and coffee. You can find Restaurant H41 in Wageningen City Centre, Heerenstraat 41, 6701 DH Wageningen.
Excursions and dinner are not included in the standard Conference fee; participating in these events requires prior registration and payment or payment on site at the conference desk.

The excursions will be guided by scientists and most of the excursions have a scientific character; some are combined with a cultural treat. Most of the excursions will leave around 08.30 at the Hof van Wageningen and return around 17.30 hrs; transport, coffee/tea, packed lunch and refreshments are included.
All our excursions include shorter or longer walking trips in the open air, so we advise you to bring watertight easy walking or hiking shoes and rain clothes with you. The average temperature in August is 19-21 degrees Celsius, with a fair possibility of rainfall.

1. A combined excursion in Wageningen: Wageningen Campus: ISRIC-World Soil Museum, NIOO, Wepal, presentation SoilCares

Excursion leader Titia Mulder, Wageningen University & Research, Section Soil Physics and Land Management

The excursion starts with a visit to the ISRIC-World Soil Museum. We will then visit the new NIOO premises including laboratories. We will take a short bus tour to WEPAL where we will have lunch and a guided tour.
The first excursion point will be **ISRIC-World Soil Information**. Since 1966 this institute is serving the international community as custodian of world soil data and information. During a guided tour through the ISRIC World Soil Museum you will be able to explore the largest soil monolith collection in the world, and learn how soils are connected to global challenges. Please visit isric.org for more information.
After this visit, we will have a short walk to the **The Netherlands Institute of Ecology, (NIOO-KNAW)**, where we will have a coffee break, a film and a guided tour.
The NIOO-KNAW studies the effect of nature in all its many forms. It is, therefore, only fitting that ecological processes and the dynamics of nature themselves influenced the design and construction of their new premises. The NIOO-KNAW has been based in Wageningen since early 2011. For the construction, the Wageningen University & Research (WUR) provided over four acres of land near the campus and in the heart of the Wageningen green knowledge center. The complex of the NIOO comprises a main building with laboratories and offices and various outbuildings such as greenhouses.
At **WEPAL** (Wageningen Evaluating Programmes for Analytical Laboratories) we will enjoy lunch, an introduction and a tour showing the premises and the preparation of the samples used in proficiency testing schemes.
Wepal is a world-leading organiser of proficiency testing (PT) programs in the fields plants, soil, sediments and organic waste. We are organising this for over 50 years and currently have over 500 participants in these PT schemes in countries all over the world. A wide variety of samples from the PT programs are also available as reference material.
After the WEPAL-tour we return to Wageningen Campus, Gaia Building for a demo of **SoilCares soil testing solutions** (SoilCares Soil Scanner and SoilCares Lab-in-a-Box).
This trip will leave at the Hof van Wageningen on 08.30 hrs and return at the Hof van Wageningen around 16.00 hours.

2. Excursion to the National Park Hoge Veluwe
(http://www.hogeveluwe.nl/en)

Excursion leader: Roel Dijksma, Wageningen University & Research, Section Hydrology and Quantative Water Management

National Park Hoge Veluwe is a relic from glaciers that covered the Netherlands during Saalien (2 104 – 1.2 104 years ago). It is a large complex of ice-pushed ridges with an elevation up to 110 m+NAP. Excess rainwater can infiltrate in the sandy soil and feeds the underlying aquifer. This groundwater rises to the surface in springs and brooks in the surrounding area. In this excursion the geology and related water management of the region will be shown. The excursion will start on top of an ice-pushed ridge with an overview to the adjacent river landscape. Then we will visit an old mill-brook, which is fed by Veluwe water, and some of the upper branches of this brook (manmade springs). This field trip is followed by a visit in the afternoon to the National Park Hoge Veluwe and the Kröller Muller Museum which hosts many famous paintings of Dutch masters such as Van Gogh. De Hoge Veluwe National Park is the largest actively managed conservation area in private hands in the Netherlands.

The Park covers 5,400 hectares of woodland, heathland, peat bogs and drift sand. It enjoys a wide variety of plants and animals and provides habitats to extremely rare Red List species.

You have the possibility to have a guided nature walk in the park or enjoy a visit to the Kröller-Müller museum on your own. This trip will leave by bus at the Hof van Wageningen on 08.30 hrs and return around 17.30 hours.

3. An excursion about 200,000 years of landscape formation in the surroundings of Wageningen: consequences for current day use

Excursion leader: Marijn van der Meij, Wageningen University & Research, Section Soil Physics and Land Management

The Saalien ice age has set the scene for today's landscape around Wageningen: the cover ice reached the area and deep depressions and pushed moraines were formed. Since then, the landscape was further shaped by a combination of climate change, geomorphological processes, soil formation, vegetation dynamics, and human influence. This excursion tells the fascinating story of this dynamic landscape and discusses the consequences for current day use.

This trip will leave by bus at 8:30 from the 'Hof van Wageningen' and 08.45 Hotel de Wageningsche Berg and returns at ca. 17.00. We will have relatively little 'bus time' but spend most of the time in the field).

Amongst the places we visit are: the Wageningse Berg, Wolfheze, Renkums Beekdal, Grebbedijk.

<u>Disclaimer:</u> The Wageningen Soil Conference-excursions are subject to availability and will be offered to participants of the Conference who have registered and paid the separate fee for an excursion. All best endeavours will be made to present the tour programme as published. However, the Wageningen Soil Conference reserves the right to alter or cancel without prior notice, any of the arrangements, timetables, plans or other items relating directly or indirectly to the tour programme for any reason beyond its reasonable control. Wageningen University & Research is not liable for any loss or inconvenience caused as a result of such alteration. **Please be aware that participants take part at their own risk. Wageningen University & Research will not be responsible for personal injury or loss or damage of property.**

AFTERNOON SIDE EVENT DURING THE WAGENINGEN SOIL CONFERENCE - AUGUST 29, 2017

You are kindly invited to participate in the Fertile Grounds Initiative side event:

Towards a circular Economy for Soil Nutrient management in Sub-Sahara Africa: from Concept to Business Case

Re-using soil nutrients is one of the keys towards sustainable agricultural intensification. However, to implement and scale nutrient re-using processes, viable business cases are essential. The Fertile Grounds Initiative (FGI) aims to close soil nutrient cycles at several levels of scale. Although the potential is there, prevailing technical, social and policy barriers hamper the adoption of more efficient soil nutrient management systems.

In this side event existing and potentially successful business cases are discussed. We wish to stimulate business cases and partnerships that can take part in the active development of the FGI concept and become involved in making the circular nutrient management reality.

We have developed an exciting programme including an investors view on selected business cases and look forward to meeting you during our event.

Location: Lumen building (100) Meeting room Lumen 1

14.00 Welcome: introduction to FGI and main findings

14.30 Presentation of business cases at global, regional and local scale

15.00 Get to work….are these cases viable for financing?

16.00 The investor's view

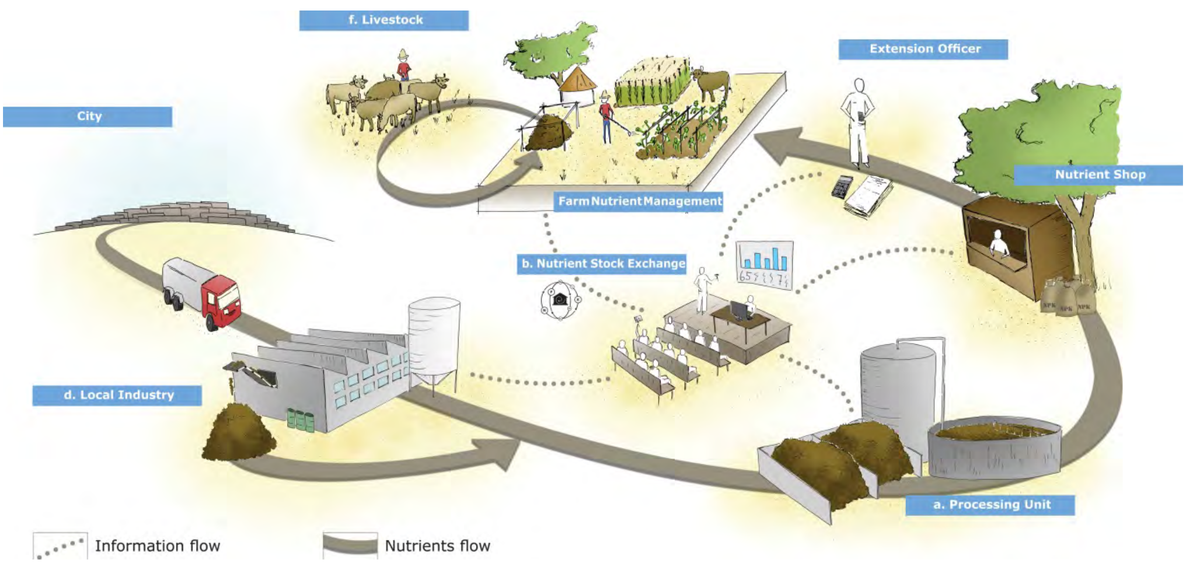
16.30 Partnerships and the role of the private sector

17.00 Closure

FGI will publish a statement paper about the major findings of this workshop.

The Fertile Grounds Initiative (FGI) aims to contribute to improved soil fertility management and nutrient trade in African countries. The paradigm behind the FGI is that there are additional sources of organic nutrients, both locally and regionally available than currently being used and that optimization of the use of such organic resources can lead to a more efficient use of inorganic nutrients. To make use of these 'hidden' resources FGI brings together various actors at different levels of scale. FGI supports two case studies in Ethiopia and contributes to networks at several levels of scale.

To attend, please send a message to Jennie van de Kolk at jennie.vanderkolk@wur.nl. Your registration is highly appreciated. For more information about FGI please visit www.fertilegroundsinitiative.info.



Wednesday, August 30st 2017

08.00 Arrival / registration – *Lobby, Orion Building (Bronland 1, Building 103, 6708 WH Wageningen)*
Poster Placement, Coffee

THEME 3: WATER RESOURCES
Chair: Sjoerd van der Zee

08.30 – 08.55 **KEYNOTE** – *Plenary meeting room (Orion 1040)*
Ryan Teuling, Wageningen University & Research, The Netherlands
The impact of soil moisture and land cover on atmospheric conditions

08.55 – 09.20 **KEYNOTE** – *Plenary meeting room (Orion 1040)*
Yan Jin, University of Delaware, USA
Coupled soil physical and biological processes in the root zone

09.20 – 09.45 Plenary discussion - *(Orion 1040)*

09.45 – 10.15 One minute poster pitches Water Resources – *Plenary meeting room (Orion 1040)*

Presented posters:

Naser Askari: Effect of Super Absorbent Polymers (SAPs) on the growth and yield of lettuce (Lactuca Sativa) in dry conditions to protect water resources

Mignon Sandor: Nitrogen Leaching From Organically Amended Soils – An Experimental Approach

Kefeng Zhang: Deduction of soil hydraulic parameters to improve capacity of hydrological model use for agricultural water management

10.15 – 10.45 Poster sessions with coffee break – *Restaurant 'The Spot', Orion building*

10.45 – 12.15 **PARALLEL SESSIONS**

2 sessions with 6 oral presentations

	Session Water Resources 1 ***(Orion 1040)*** *Chair: Sjoerd van der Zee*	**Session Land Functions 1** ***(Orion 2051)*** *Chair: Taru Sanden*
10.45 – 11.00	*Ruud Bartholomeus* Matching agricultural freshwater supply and demand: using industrial and domestic treated wastewater for sub-irrigation purposes	*Erik van den Elsen* The CASCADE project - understanding and prevention of sudden ecosystem shifts in Mediterranean drylands
11.00 – 11.15	*Rudi Hessel* The WAHARA project: water harvesting for rainfed Africa	*Miriam Muñoz-Rojas* Soil strategies for restoring land functionality in degraded drylands
11.15 – 11.30	*Naftaly Goldshleger* Mapping water content of unsaturated agricultural soils using ground-penetrating radar	*Inigo Virto* Methodological considerations in the study of soil stoniness. A case-study in a Mediterranean irrigated gravelly soil
11.30 – 11.45	*Domingo Jariel* Retention of lead and arsenic in cajun prairie soils of Louisiana	*Mark Caulfield* Environment-Management interactions drive soil-based agro-ecosystem characteristics in a rural Andean landscape
11.45 – 12.00	*John Parsons* Biodegradation of water treatment additives: transformation and byproduct formation, impact of biocide shockdosing and salinity	*Kurniatun Hairiah* Soil health in oil palm plantations: managing soil organic matter
12.00 – 12.15		*P.K. Basavaraja* Sub surface drainage- Boon to command areas of Karnataka for enhancing crop production
12.15 – 13.30	Lunch & Poster sessions – *Restaurant 'The Spot', Orion building*	

THEME 4: LAND FUNCTIONS

Chair: Rachel Creamer

13.30 – 13.55 **KEYNOTE** – *Plenary meeting room (Orion 1040)*
Taru Sanden, Austrian Agency for Health & Food Safety (AGES), Austria
Sweet spots of multifunctionality in arable soils

13.55 – 14.20 **KEYNOTE** – *Plenary meeting room (Orion 1040)*
David Wall, Agriculture and Food Development Authority, Teagasc, Ireland
The multi-functionality of grasslands for delivering soil based ecosystem

14.20 – 14.45 Plenary discussion - *(Orion 1040)*

14.45 – 15.15 One minute poster pitches Land Functions– *Plenary meeting room (Orion 1040)*

Presented posters:

Ademir Sergio Ferreira de Araujo: Time-dependent effect of composted tannery sludge on the chemical and microbial properties of soil

Nicolas Beriot: Plastic mulch debris impact on soil properties

Amelie Baomalgre Bougma: Soil physical and hydraulic properties of ‘forest islands’ and adjacent ecosystem types in West Africa

Ingeborg Callesen: Soil texture analysis by laser diffraction – standardisation needed

Andrea Čerevková: Changes within nematode communities in windthrown European montane spruce forests after disturbance by fire

Naixin Fan: Spatial patterns of soil carbon turnover times using multiple datasets

Maria Cristina Margarita Frugoni: Good forest practices and healthy soils. a sound association in North Patagonia, Argentina

Kristina Ivaschchenko: Soil microbial biomass, microbial respiration, fungi-to-bacteria ratio under different land use in moscow region

Samuel Ayodele Mesele: Soil mineralogy of forest islands of West Africa

Hryhorii Moroz: Contrast ratio as an important characteristic of sois in the Northwest of the Black Sea region

Miriam Muñoz-Rojas: New strategies in mine rehabilitation: application of cyanobacteria to enhance soil functions

C.N. Nalina: An assessment of water table depth and water quality dynamics in salt affected rice soils of Bhadra command, Karnataka

Yueling Qi: Occurrence of microplastics in argriculture soils of Northwestern China

Lalaina Ranaivoson: Soil nitrogen availability for rice under conservation agriculture systems in the lake Alaotra region, Madagascar

Danny Dwi Saputra: Do cacao agroforest resemble forest? Root density, soil macropore and soil infiltration

Jeroen Schoorl: Consequences of uncertainty in field observations of soil depth for digital soil mapping of soil functions

Evgeny Shein: Granulometric composition as a predictor of pedotransfer functions: use of laser diffraction and sedimentometric methods

Bożena Smreczak: Soil monitoring for CAP evaluation in Poland

Peipei Yang: Crop yield remedies and soil improvements of soil-compaction-relieving-measures, a meta-analysis

Xiaomei Yang: Synergies of microplastic and glyphosate transport in the soil ecosystem with earthworm galleries: a mesocosms approach

15.15 – 15.45 Poster sessions with coffee break – *Restaurant 'The Spot', Orion building*

15.45 – 17.15 **PARALLEL SESSIONS**

2 sessions with 6 oral presentations

Session ISRIC Special Session
(Orion 1040)
Chair: Gerard Heuvelink

15:45 – 15:51: *Gerard Heuvelink*
Introduction

15.51 – 16.03: *Bernard Ahrens*
The use of SoilGrids to parameterize and Evaluate a Global SOC profile Model

16.03 – 16.15: *Jetse Stoorvogel*
Assessing the global potential for soil carbon sequestration using The s-world global soil property database

16.15 – 16.27: *Dominique Arrouays*
The GlobalSoilMap project

16.27 – 16.39: *Ben Schaap*
Towards global soil data interoperability: GODAN soil data WG and SOILML (open) data exchange format

16.39 – 16.51: *Kris van Looy*
Global CZO and lter site data and model application

Session Land Functions 2
(Orion 2051)
Chair: David Wall

15.45 – 16.00: *Rudi Hessel*
The RECARE project: Preventing and Remediating degradation of soils in Europe through Land Care

16.00 – 16.15: *Anja-K. Techen*
Changing Pressures on Soils - a foresight study on soil management in Germany

16.15 – 16.30: *Joachim Deru*
Soil ecology and ecosystem services of dairy and nature grasslands on peat

16.30 – 16.45: *Giulia Bondi*
Assessing soil structural quality in Irish grassland soils

16.45 – 17.00: *Lieselot Boone*
Modeling Soil Organic Carbon management in cropfields. Introduction of a resource based indicator to account for remediation actions

16.51 – 17.03: *Johan Leenaars*
Mapping of fertilizer recommendations for major crops in West Africa

17.03 – 17.15: *Christian Folberth*
Uncertainty in soil data and implications for global gridded crop modelling

17.00 – 17.15: *Wim de Vries*
Assessing changes in soil nutrient status in response to different forest harvesting practices

17.15 – 19.15 ISRIC Special Event: Launch Soil Data Facility of the Global Soil Partnership
Drinks & Bites & poster sessions – *Restaurant 'The Spot', Orion building*

ISRIC invites you for drinks & bites to celebrate the launch of the Soil Data Facility

We are happy to announce that ISRIC – World Soil Information has been elected to host the Soil Data Facility of the Global Soil Partnership!

Attendees will have the chance to learn how they can benefit from, support and add value to the Soil Data Facility, learn how ISRIC will take on their new role, what the objectives are of the Global Soil Partnership. We have a special guest reflect on the importance of soil data in the context of global issues. This special speaker will be announced soon!

<u>About the Soil Data Facility and the Global Soil Partnership</u>
On 20th June 2017 the Plenary Assembly of the Global Soil Partnership (GSP) selected ISRIC – World Soil Information to host the Soil Data Facility that will be developed as part of Pillar 4 of the partnership. This means that ISRIC will (i) contribute to the design of the Global Soil Information System, (ii) participate in capacity building programs and (iii) provide a system that integrates the national facilities into a global soil information system.

The Global Soil Partnership (http://www.fao.org/global-soil-partnership) was established in December 2012. Its mandate is to improve governance of the limited soil resources of the planet to guarantee agriculturally productive soils for a food secure world, as well as support other essential ecosystem services. For the GSP to achieve its mandate, they address 5 pillars of action to be implemented in collaboration with its regional soil partnerships.

Pillar 4 of the GSP addresses the development of a Global Soil Information System and requires the active participation and contribution of national soil information institutions. For this, an International Network of Soil Information Institutions (INSII) has been established (see figure below). ISRIC, in their new role of Soil Data Facility, will assist the INSII to build national and regional soil information systems and will integrate these by providing a central global soil information system.

ISRIC is proud to be trusted this important role by the Plenary Assembly of GSP and will continue to work closely together with the Pillar 4 Working Group and INSII to contribute to the a sustainable use of the global soil resources.

Thursday, August 31st 2017

08.00	Arrival / registration – *Lobby, Orion Building (Bronland 1, Building 103, 6708 WH Wageningen)* Poster Placement, Coffee

THEME 5: BIODIVERSITY
Chair: Peter de Ruiter

08.30 – 08.55	**KEYNOTE** – *Plenary meeting room (Orion 1040)* *Gerlinde de Deyn, Wageningen University & Research, The Netherlands* Unlocking the potential of soil biodiversity for the SDGs
08.55 – 09.20	**KEYNOTE** – *Plenary meeting room (Orion 1040)* *George Kowalchuk, Utrecht University, Utrecht, The Netherlands* Defining rules of microbial diversity and community assembly in soil
09.20 – 09.45	Plenary discussion - *(Orion 1040)*
09.45 – 10.15	One minute poster pitches Biodiversity – *Plenary meeting room (Orion 1040)* *Ludovit Cagan:* Effect of insecticides to soil nematode communities in maize field *Ana Roberta Lima de Miranda:* Soil bacterial diversity after eight years of composted tannery sludge amendment *Sarka Polakova:* Pesticides monitoring in the agricultural soils in the Czech Republic *Mirjam Pulleman:* Diversification of tropical pastures; key to C sequestration and improved soil health? *Nadezda Verkhovtseva:* Composition of microbial community at biodegradation of different plant litter *Fabio Vicentini:* Springtails grouping in post mining sites characterization *Miao Yu:* Leaching risk of microplastics by preferential flow in biogenic tunnels (earthworm burrows)
10.15 – 10.45	Poster sessions with coffee break – *Restaurant 'The Spot', Orion building*

10.45 – 12.15 **PARALLEL SESSIONS**

2 sessions with 6 oral presentations

	Session Biodiversity 1 ***(Orion 1040)*** *Chair: Gerlinde de Deyn*	**Session Food Security 1** ***(Orion 2051)*** *Chair: Boris Jansen*
10.45 – 11.00	*Jeroen van Leeuwen* Soil food web assembly and vegetation development in a glacial chronosequence in Iceland	*Yoshie Yageta* Farmers' Mental Model for their Perception of Soil Process and Property, case Study in Kitui, kenya
11.00 – 11.15	*Elly Morriën* Changes in Soil biota Networks during secondary succession: Is it biodiversity or network structure that determines soil function?	*Yihenew Selassie* Organic Fertilizer at a Cross Road Between Soil health and Food Security: Case Study from Western Amhara Region, Ethiopia
11.15 – 11.30	*Nadejda Soudzilovskaia* How abiotic environment affects plant species richness within distinct Mycorrhizal types?	*Tamara Jonkman* Sustainability of vegetable gardening in the urban surroundings of Kisumu, Kenya and Ouagadougou, Burkina Faso
11.30 – 11.45	*Annemieke Kooijman* Abiotic and biotic drivers in P-nutrition in calcareous and acidic dune soils with different soil organic matter content	*Meskerem Abi Teka* How farmers' characteristics influence spontaneous spreading of stone bunds in the highlands of Ethiopia: A case study in the Girar Jarso woreda
11.45 – 12.00	*Janna Barel* Legacy effects of diversity in space and time driven by winter cover crop biomass and nitrogen concentration	*Eyasu Elias* Characterization and mapping of soils in the Ethiopian highlands and implications for soil fertility management decisions at farm level
12.00 – 12.15	*Giulia Bongiorno* Determination of soil quality indicators by labile carbon and nematode communities in 10 european long-term agricultural field trials	*Jones Yengwe* Nitrogen mineralization and biological properties of soils from under canopies of contrasting faidherbia albida trees ages following litter amendment

12.15 – 13.30 Lunch & Poster sessions – *Restaurant 'The Spot', Orion building*

THEME 6: FOOD SECURITY
Chair: Ken Giller

13.30 – 13.55 **KEYNOTE** – *Plenary meeting room (Orion 1040)*
Shamie Zingore, International Plant Nutrition Insitiute, Kenya
Low crop yields and yield quality in sub-Saharan Africa: the soil quality and nutrient management nexus

13.55 – 14.20 **KEYNOTE** – *Plenary meeting room (Orion 1040)*
Pablo Tittonell, Instituto Nacional de Tecnología Agropecuaria (INTA), Argentina
Soil Science and Food Security: embracing sustainability, complexity and uncertainty

14.20 – 14.45 Plenary discussion - *(Orion 1040)*

14.45 – 15.15 One minute poster pitches Food Security – *Plenary meeting room (Orion 1040)*

Presented posters:

Mousumi Akter: Organochlorine Pesticides Residues in Soil, Vegetable and Milk in horticulture regions of North East Bangladesh

Kindu Gashu Aynalem: Assessment of a prototype decision support tool for nutrient management within the framework of functional land management at community level within Northern Ethiopia

Lambert Brau: Enhancement of phosphate acquisition and delivery to plants using the cyanobacterium Nostoc punctiforme

Reda Gidena: Applying a diagnostic approach to soil classification and to explain and manage nutrient cycling in ethiopian soils of Northern Amhara and Tigray regions

Mirjam Pulleman: Agroforestry-based restoration for enhanced resilience of agricultural production in the dry corridor of Central America

Tanvi Taparia: Mushroom Health: A systems study

Eka Tskitishvili: Plant Parasitic Nematodes Assemblages Associated With Potato In Tetritskaro (Eastern Georgia)

15.15 – 15.45 Poster sessions with coffee break – *Restaurant 'The Spot', Orion building*

15.45 – 17.15 **PARALLEL SESSIONS**

2 sessions with 6 oral presentations

	Session Biodiversity 2 ***(Orion 1040)*** *Chair: Lijbert Brussaard*	**Session Food Security 2** ***(Orion 2051)*** *Chair: Shamie Zingore*
15.45 – 16.00	*David Spurgeon* Developing a framework for interspecies extrapolation in soil ecotoxicology	*Matt Keller* Utility of handheld, low cost spectroscopic devices for soil and plant tissue analysis
16.00 – 16.15	*Esperanza Huerta Lwanga* Can Earthworm gut bacteria remediate microplastic contaminated soils?	*Christy van Beek* Uptake and impact of on the spot fertilizer recommendation for smallholder farmers in kenya using sensor technology
16.15 – 16.30	*Ekaterina Kovaleva* The evaluation of oil contaminated soils in time (the Northern part of Sakhalin Island)	*Rachel Creamer* Developing a decision support tool for on-farm nutrient management in northern Ethiopia
16.30 – 16.45	*Jan Frouz* Soil restoration in various reclamation techniques in comparison with unassisted recovery	*Sheikh Rabbi* Roots redesign the soils physical architecture and function for drought-tolerant plants
16.45 – 17.00	*Jabbar Moradi* Can soil arthropod species diversity, in post-mining unreclaimed sites, benefit from some level of intervention? A case study in sokolov post-mining sites, Czechia.	*Jeroen Pijlman* Soil and weather variables in relation to the annual mineral nitrogen supply of dairy grasslands on peat soils in The Netherlands
17.00 – 17.15	*Nadezda Vladimirovna Verkhovtseva* Structural changes of phytocenose and microbial community after long–term application of glyphosate	*Egidijus Sarauskis* Analysis of CO2 emissions from agricultural soils and machineries under different tillage systems in maize

17.15 – 18.15 **CONFERENCE CLOSURE** – Jakob Wallinga
Drinks & Bites & poster sessions – *Restaurant 'The Spot', Orion building*

Theme 1

Governance and Policy

Keynote

Annette Schneegans

SOILS IN THE EU – AGRICULTURAL POLICY AND RESEARCH WORKING IN TANDEM TO SPUR INNOVATION

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Agriculture is one of the main beneficiaries of the manifold functions and ecosystems services provided by soils. Despite the heavy reliance on this precious resource, agricultural practices, in particular in intensive systems, are contributing to soil degradation and loss of functions. As a result, agricultural soils - representing about half of Europe's land area (80 % including forestry) - are facing mounting pressure as manifested by soil erosion, soil compaction or low content of soil organic matter.

There is no legally binding policy framework for the protection and restoration of soils at European level. However, a number of EU policies, strategies and initiatives address land use, soil quality and functions – mostly in the context of protecting other natural resources such as water and biodiversity or of sustainability goals entrenched in sectoral policies. The Common Agricultural Policy (CAP) is a main driver for agricultural practice in agriculture, determining to a significant extent how farmers produce and how they manage the underpinning resource base. While not setting explicit, quantitative objectives for soil quality or soil management, the "Sustainable management of natural resources" (including soils), is one of three general objectives of the CAP 2014 -2020. Its multitier structure provides a supporting framework for tackling soils at individual farm level as well as at collective, landscape or regional levels. The CAP has thereby far reaching potential to steer land management decisions across farms and forests.

The three main instruments relevant for soil management and the delivery of soil services under the CAP are (1) the cross-compliance requirement based on existing EU legislation and standards for Good Agricultural and Environmental Condition of Land (GAEC), (2) Pillar I greening payments and (3) several measures under Pillar II Rural Development Programmes (RDPs). RDPs also include forest measures and target forest soils. In implementing the CAP, Member States have considerable flexibility in the choice and design of measures according to the characteristics of agricultural production or pedo-climatic conditions in their regions. In consequence, there is large variation between Member States as to the degree of soil protection provided through CAP instruments.

A specific measure under RDPs provides support for the set-up of "operational groups" (OG) linked to the work of the European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI). The EIP-AGRI seeks to promote the uptake of innovations in agriculture by bridging research and practice. Its implementation is based on local/regional innovative projects developed by OGs. These groups are very effective in bringing together farmers, advisors, researchers and other players with complementary knowledge to work jointly on a specific problem or opportunity. As implementation of RDPs in the 2014-2020 is gaining momentum, currently more than 300 OGs across the EU are exchanging experiences through the EIP network and creating an extensive web of knowledge in various domains, many of which are relevant to soil management. Focus Groups under the EIP-AGRI are further contributing to pooling practice oriented knowledge on specific subjects, including on resource efficiency and soil management in agriculture. Outputs delivered by Focus Groups include recommendations for practitioners in farming and the identification of knowledge gaps, the latter one being a potential input for programming under the European Research Programme Horizon 2020 (2014 – 2020).

Under Horizon 2020, funding for soil related matters is mainly channelled through Societal Challenge 2 (Food Security, Sustainable Agriculture and Forestry, Marine, Maritime and Inland Water Research and the Bioeconomy) and Societal Challenge 5 (Climate Action, Environment, Resource Efficiency and Raw Materials). Horizon 2020 projects funded in the agricultural domain (e.g. LANDMARK, iSQUAPER or SOIL CARE) represent major hubs for European soil research and for testing the "multi-actor approach" in line with the EIP-AGRI principles of "interactive innovation". The diversity of partners and expertise assembled in multi-actor projects is seen as an asset, changing the ways in which research is conducted and its outcomes are translated into applicable knowledge.

The in-built synergies between CAP, the EIP-AGRI and Horizon 2020 form an "innovation policy triangle" which is a novelty in itself. It reflects the increased recognition of agricultural knowledge and innovation systems as the missing link between insights from science and their impact on the ground. The wealth of on-going, soil related activities under the umbrella of CAP OGs, EIP Focus Groups and Horizon 2020 research projects and thematic networks is a unique starting point for building a shared understanding of soil challenges and opportunities for soil management in agriculture and forestry.

Upcoming discussions on the forthcoming CAP and European Research Programme provide opportunities for enhancing the current innovation framework and for embedding soil considerations more firmly into EU policy instruments.

Keynote

Simon Moolenaar

LANDSCAPE RESTORATION FOR SUSTAINABLE DEVELOPMENT: A HOLISTIC BUSINESS APPROACH

MOOLENAAR, S.W.[1] (SIMON.MOOLENAAR@COMMONLAND.COM); FERWERDA, W.H.[2]

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[2] CEO of Commonland, The Netherlands

The global landscape restoration community is entering a new era that is characterized by projects that are large-scale, economically-viable and socially-inclusive. Large investment funds are getting ready to participate. However, the project-pipeline to accommodate this kind of investments is missing. We need to scale up, to speed up and do this smart. Commonland envisions large-scale landscape restoration activities involving businesses by building transformative business cases with local farmers, land users, and experts. In this way, the urgent need for project pipelines towards (institutional) investors will be bridged. The impact of Commonland projects translates into 4 returns® on investment: return of inspiration, return of social capital, return of natural capital, and return of financial capital.

Commonland is road-testing this approach in landscapes in Australia, South Africa, Spain and the Netherlands. Our goal is to deliver proof of concept for large (institutional) investors to participate in the transformation of large-scale restoration projects into pipeline ready investment opportunities. Designing and implementing restoration projects that are effective, efficient, and engaging will enable businesses and investors to reduce risks and cost-effectively scale-up restoration efforts. Consequently, these will become part of mainstream activities and investment portfolios by the private sector. A more elaborate description of our projects can be found in Ferwerda & Moolenaar (2016).

At the Wageningen Soil Conference we will explain the 4 returns approach, the challenges and the lessons learned from implementing restoration projects according to this approach for enhancing the project pipeline for investable restoration initiatives.

Based on our experiences, research needs will be addressed, potential contributions from soil science and business curricula will be discussed and policy recommendations for the next CAP reform will be based on our vision for integrated landscape restoration as a means towards a better environment and a more sustainable agriculture.

Background

The Wageningen Soil Conference highlights the “importance of soil science for combating and mitigating the challenges of our time: food security, water resources, climate change, ensuring biodiversity and land functions and how to govern these issues and create effective policy measures”.

Healthy soils, ecosystems and landscapes are at the heart of a sound and sustainable economy. However, our economies are based on production methods and consumption patterns that generate jobs and short-term wealth, while simultaneously degrading and destroying the ecosystems that form the very basis of this wealth creation.

Restoring damaged ecosystems is therefore essential to reversing the depletion of our primary asset and keeping ecosystems functioning for future generations. UNEP, the UN Convention to Combat Desertification (UNCCD) and the World Resources Institute (WRI) estimate that there are 2 billion hectares (double the size of the USA) of severely degraded land suitable for rehabilitation through forest and landscape restoration. Of that area, 1.5 billion hectares are suited to mosaic landscape restoration, in which forests and trees are combined with other land uses, including agroforestry.

Current efforts to scale-up restoration are not succesfull enough. While several NGOs and farming and governmental organizations are working hard on ecosystem restoration, business, farming and ecological interests are generally not well aligned or integrated. In spite of international intentions such as those of the ministerial Bonn Challenge on forest landscape restoration (www.bonnchallenge.org), efforts to restore damaged ecosystems continue to fall short of stated goals. Restoration efforts must be scaled up urgently.

In the coming years, public and private sector collaboration will likely be a key component in furthering work on landscape restoration. Private sector decision-makers will need to understand ecosystem concepts. Public sector decision-makers will need to understand corporate processes. This type of joint effort was codified in SDG 17, which is about creating partnerships as a critical success factor to achieve any of the other goals, like that of SDG 15 on land. SDG 17.17 states: to “encourage and promote effective public, public-private and civil society partnerships, building on the experience and resourcing strategies of partnerships.”

That is exactly what Commonland wants to realize on the ground: multistakeholder partnerships that realize large-scale landscape restoration projects based upon viable business models. To realize such collaborative efforts, an orchestrator is needed to actively compose cross sector partnerships which are required to mobilize and engage the expertise and resources of the various communities needed to restore a landscape: local people, land managers, scientists, entrepreneurs and business professionals, investors, governments and NGO’s. We call these multiple stakeholder partnerships “Landscape Restoration Partnerships”. Such Landscape Restoration Partnerships could be an association or co-operation of farmers, land owners and land users, using expert knowledge from scientists and entrepreneurs, and financed by investments based on a common landscape vision for long-term and large-scale restoration.

An innovative framework with a common language is needed so that the landscape is viewed in a holistic way taking a long-term (intergenerational) viewpoint.

To facilitate the creation of these partnerships and formulate a common vision, Commonland has developed a holistisc approach called the 4 returns, 3 zones, 20 years framework (Ferwerda, 2015). This approach offers practical incentives for farmers, land users, companies and investors that will give 4 returns: a return of inspiration (hope, purpose, meaning), return of social capital (employment and engagement), return of natural capital (biodiversity, resilience, ecosystem functions), and return of financial capital (see also Figure 1).

Dividing landscapes into three zones makes the goals clear to all stakeholders: a natural zone (restoring biodiversity, hydrology and topsoil); a combined or eco-agro mix zone (restoring ecology with productive species, like agroforestry); and an economic zone (agriculture, processing products, real estate, etc). We refer to Figure 2 for more explanation.

Long-term commitment is important, as it takes approximately 20 years, or one generation, to restore a landscape. That is why the 4 returns approach adopts a 20 years horizon.

Using this approach based on collaborative management and new connections with local implementing partners, combined with business-driven solutions and investments, the significant scaling-up of current projects and the restoring of millions of hectares of degraded landscapes is aimed for (see schematic representation in Figure 3).

Further reading

Ferwerda, W.H. (2015). 4 returns, 3 zones, 20 years: A Holistic Framework for Ecological Restoration by People and Business for Next Generations. RSM/IUCN CEM. (second revised version on www.commonland.com)

Ferwerda, W.H. & S.W. Moolenaar (2016). Four Returns: A Long-term Holistic Framework for Integrated Landscape Management and Restoration Involving Business. Solutions Journal September-October: p. 36-41 (www.thesolutionsjournal.org)

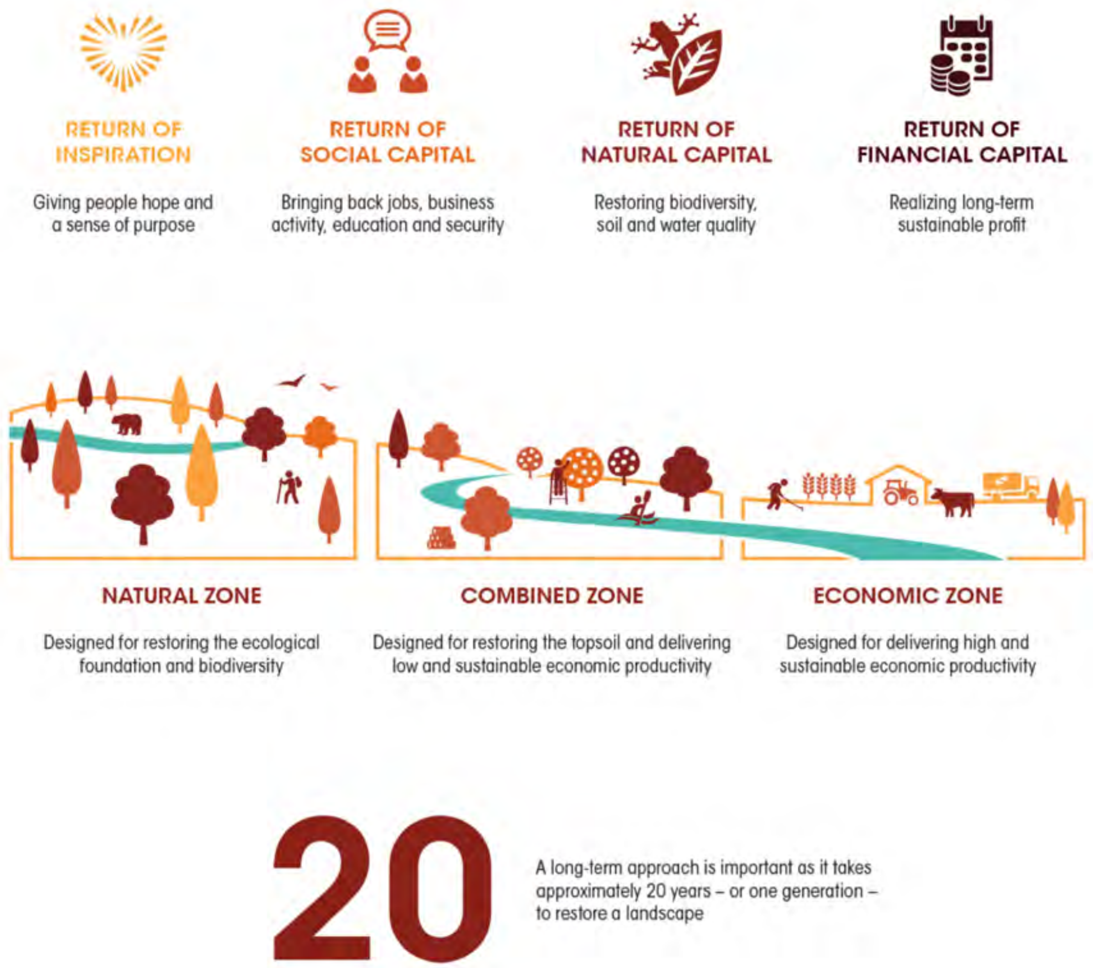

Figure 1. Commonland's 4 returns, 3 zones, 20 years approach.

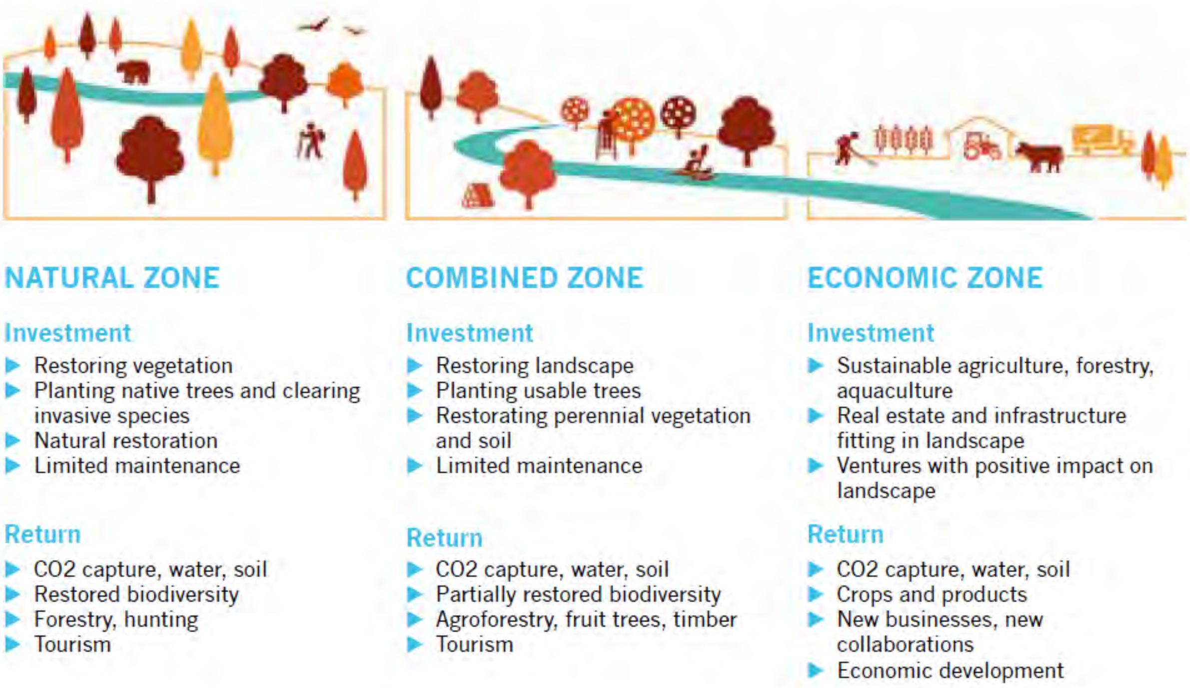

Figure 2. Commoland's approach to the three landscape zones.

Figure 3. Representation of the 4 returns restoration masterplan, reflecting the way investments and grants are put to work.

Parallel session
Governance and Policy 1

SOILASSIST – ASSISTING FARMERS TO REACH THE SDG GOALS 12 AND 15

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With a possible reform of the CAP at a tipping point, and the UN Sustainable Development Goals (SDGs) in focus, there is though a lack of information on how to cope with EU regulations. In Germany, the new fertiliser ordinance may reduce the amount of on-field working days and may provoke a shift to manure spreading associated with field traffic in a wet soil period in spring. In our presentation, we will point out how the project SOILAssist comes up with this challenge and others. SOILAssist – as a part of the funding initiative BONARes – provides data and guidelines to applied soil science as well as farmers – and on the other hand, does collect farmer's opinions and perceptions of agricultural extensionists to weave a strong rope of an initial anti-soil-compaction narrative.

With the goal to end hunger, achieve food security and improved nutrition and promote sustainable agriculture, the SDGs point at the various functions of soils. But often, optimizing one soil function is at the expense of another. BONARes-SOILAssist project members are trying to develop a decision support system (DSS) that guides the driver of agricultural machinery on how to meet the needs of the local soil and on how to adjust his or her action in a site-adapted way to promote sustainable use of (agro-)ecosystems (SDG Goal 15) and ensure sustainable production (SDG Goal 12).

This abstract refers to the project "SOILAssist" launched in October 2015 as a part of the German research program 'BonaRes – Soils as Sustainable Resource for the Bioeconomy' (funded by the Federal Ministry for Education and Research, BMBF 031A563A).

SMART TOPSOIL RELOCATION TO MITIGATE LAND TAKE IMPACT ON SOIL RESOURCES

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As the European Guidelines on Soil Sealing state, each year an amount of land surface equal to Berlin City is taken for conversion into urban built area and infrastructure. Vast amounts of topsoil are left to contractors who give it a new destination. Current legislation and governance structures fail to facilitate soil stewardship. Smart relocation options are not encouraged in tender procedures. Contractors use to find their way in civil engineering environments, and lack feeling with ‘farmers’ needs. As a result, a significant part of ‘obsolete’ fertile topsoil is brought to destinations where their fertile features are hardly needed or even disadvantageous. For instance in the Netherlands former sandpits, left as deep ponds, use to be filled back with that fertile topsoil, demanding additional measures to prevent surface water eutrophication.

Currently, just 5 km from Wageningen, an eco-restoration project is being prepared. Lowering the land surface by removing 600,000 m^3 fertile topsoil is envisaged to recover the original boggy wetlands and associated birdlife over 5 km^2. The removed fertile topsoil, which has been carefully built up by farmers over the centuries, may be processed in a high rising, of which the surface would continue delivering ecosystem services. However, below 0.3 m-gl conditions are such that in this case total of approximately 3,000 tonnes of well-balanced grassland soil organisms would die. What would be needed to realise a better solution for this surplus soil?

In 2016, the province of Gelderland issued a five year programme to stimulate circular use of soil, including knowledge development in practice and support to scientific research on sustainable topsoil management. The province assigned Royal HaskoningDHV to study the mechanisms and drivers provoking waste of topsoil and to find the key for transition to conservation of topsoil resources. The results are expected by August 2017.

ETHNOECOLOGICAL KNOWLEDGE EXCHANGE AND PARTICIPATORY LAND USE PLANNING: THE CASE OF SISA POLICY IN THE AMAZON KAXINAWA NOVA OLINDA INDIGENOUS LAND

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Use of participatory approaches to incorporate local knowledge into environmental policies is considered essential to foster sustainable land use. In this paper, we examine planners' and indigenous classificatory/interpretative systems of soils and how these are integrated in participatory land use planning. We report on a case study in the *Kaxinawa Nova Olinda* Indigenous Land (Acre - Brazil), where the System of Incentives for Ecosystem Services (SISA) policy is being implemented towards environmental conservation and social well-being. The paper focuses on: 1) the similarities and differences between indigenous' and planners' knowledge as expressed through soil and landscape indicators used for land use and soil management decision-making; 2) the knowledge exchange process within land use co-design. A rich body of ethnoecological/ethnopedological data was collected by means of interviews, participant observation, soil sampling, and participatory mapping. Comparative analysis reveals that indigenous soil classification, which is based on landscape and soil morphological (mostly), chemical and physics characteristics, identified 7 first level soil classes and 10 specific classes that differed in geomorphology, drainage, soil consistency, colour, texture and fertility. In contrast, soil scientists did not focus on morphology, considered pedogenetic processes and chemical/physical measurements to classify soils, and identified 7 first level soil classes and 64 specific classes. Subsequently, planners and indigenous exchanged knowledge in a joint workshop, where their taxonomic systems were aligned, coproducing 7 main soil classes: *Mai bena pâpa Maxia* (Gleysol), *Mai bena kuru kaya kesha* (Regosol), *Mai kuî bena kaya* (Cambisols), *Mai kuî sese* (Plinthosols), *Mai taxipa* (Luvisol), *Mai taxi maxi husia* (Acrisol) and *Mai kuî tesh kaya* (Vertisol). Knowledge alignment was based on the main local criteria for soils' stratification (land's agricultural suitability), and aimed at enabling communication to foster agroforestry oriented soil management. We conclude by reflecting on the scientific/social implications and power dynamics involved in knowledge exchange process.

LAND AND SOIL MANAGEMENT: STRUCTURING EMPIRICAL KNOWLEDGE ABOUT SOIL FUNCTIONS USING MULTI CRITERIA DECISION ANALYSIS

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[1] Crops, Environment and Land Use Programme, Teagasc, Wexford, Ireland
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[6] Department of Biology, University of Antwerp, Antwerp, Belgium
[7] Joint Research Centre of the European Commission, Land Resources, Ispra, Italy
[8] Agricultures & territoires, French Chambers of Agriculture, Paris, France
[9] Department of Knowledge Technologies, Jozef Stefan Institute, Ljubljana, Slovenia
[10] Jozef Stefan International Postgraduate School, Ljubljana, Slovenia

The challenge for soil science research is to be inter- and transdisciplinary, to address food security and environmental sustainability and to transfer knowledge to outsiders efficiently.

The LANDMARK multi-actor project engages its end users into research activities from its beginning. The aim is to provide valuable tools, indicators and guidelines on land and soil management, that optimize the supply and demand of a range of ecosystem services known as soil functions, specifically: i) primary production, ii) carbon sequestration, iii) water provision and purification, iv) habitats for biodiversity and v) nutrient re-cycling, all in different magnitude and proportion.

We harvested existing stakeholder knowledge at three levels: i) local farmers and advisors, ii) regional/national, iii) European actors and policy makers. Through 32 structured Functional Land Management workshops we covered different pedo-climatic zones and land uses across five European countries (France, Ireland, Denmark, Austria and Germany). At each workshop, we first harvested empirical knowledge of participants on their perception of soil quality and prioritization of soil functions. Secondly, we interactively discussed land use changes, management practices and critical knowledge requirements. The collected results have been harmonized. However to analyse and to make them structured and comparable across different pedo-climatic zones, land uses and stakeholder groups, presents a considerable methodological problem. Therefore, we used a methodology originally developed for Multi Criteria Decision Analysis (MCDA) to generate qualitative multi-attribute decision models (MADM) with DEXi modelling software. Results demonstrate the different stakeholders' perceptions and priorities about the implementation of a) management practices, b) actions and tools and c) policies, related to each soil function. The results will drive the delivery of the project outcomes creating end-users ownership.

The work is part of the LANDMARK (LAND Management: Assessment, Research, Knowledge Base) project, funded by the EU's Horizon 2020 research and innovation programme under grant agreement No 63521.

APPROACH TO THE ASSESSMENT OF LAND USE OPTIMISATION WITHIN THE CONTEXT OF CLIMATE POLICIES OF LATVIA

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[1] Latvia University of Agriculture, Latvia

In recent years the concept of land functions and its relations with land use changes has become topical as currently one of the major challenges for policy and scientific community is to understand the impacts of land use changes on sustainability. The aim of this research is to develop concept and methodology for optimisation of exploitation of land resources in Latvia. The present research focuses on three "productive" functions of land: primary production; GHG emissions and carbon capture; and environmental protection. Primary production involves three industries: forestry, agriculture and aquaculture. An approach to assessing the performance of land regarding the various functions of the land has to allow comparing the functions of the land, which are classically measured in different units of measurement. The present research measures effects from forestry and agricultural activity in terms of money, emissions and their capture are expressed in kilograms of methane, nitrous oxide, carbon and carbon dioxide, while environmental protection is measured in biological units of measurement. However, such an approach does not allow mutually comparing different values in a direct way. The values have to be recalculated into comparable (value) units. However, an approach to the recalculations has to be made as simple as possible in order to be able to perform the research within the limits of available resources. For the mentioned reasons, the present research has developed an approach that allows mutually comparing various land functions.

INTEGRATED ASSESSMENT MODELLING FOR PREVENTING AND MITIGATING SOIL THREATS: THE ROLE OF EUROPEAN POLICIES, LAND USE AND LAND MANAGEMENT

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Soils are of crucial importance for the well-being of human society as they provide a wide variety of functions and services including biomass production, filtering of water, and carbon storage. However, worldwide soils are threatened by a range of processes leading to amongst others soil sealing, erosion and a decline in soil organic matter. These processes include a multitude of drivers and disciplines, some impacting on soils instantaneously, others only become apparent over decades. Preventing and mitigation these soil threats therefore requires an integrated and long-term approach.

The EU FP7 project RECARE develops a spatially explicit and dynamic integrated assessment model (IAM) that allows to assess the impact of (European) policies, land use and land management on a range of soil threats. It uses a soil-related ecosystem services (ES) framework to communicate the implication of changes to soil properties and processes over time. The ES framework reflects the specific contributions soils make to ecosystem services by linking natural capital, soil processes, the provision of ecosystem services and their valuation. Changes in ecosystem services caused by soil threats are explicitly addressed in the framework, as well as the land use, land management and policy instruments impacting on soil. The integrated assessment model is applied to Europe and targeted towards supporting the analysis and development of EU-wide policies. It simulates how socio-cultural, economic and physical drivers impact on the natural capital and the soil processes and so demonstrates what the role of land use, land management and policies is in the aggravation, prevention and mitigation of soil threats. The spatially explicit nature of the model allows to incorporate contextual factors of the different regions in Europe to support a place-based approach. In order to ensure its relevance, interaction with users is ensured throughout the development process.

Special parallel session

Sustainable Development Goals

LAND DEGRADATION NEUTRALITY (LDN): AMBITION AND OPERATIONAL ASPECTS FOR STAKEHOLDERS

In 2015 the SDG's were adopted by all UN member states and since then the states have been trying to come up with ways how to implement SDG 15.3. By 2030, all states should have accomplished to stopdesertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world.

Wageningen Environmental Research wants to publish a discussion paper about ambition of LDN 15.3 and give direction to how this can be done in practice (keynote Saskia Keesstra). However, this paper will be more valuable with your contribution as a stakeholder. There is a urgent need for practical operational instruments and indicators.

This special SDG session aims to identify instruments and indicators that are meaningful for reaching the SDG 15.3 and that are fit for practical use by you as stakeholders.

Theme 2
Climate change

Keynote

Daniel Richter

SOIL PRODUCTION, EARTH'S CRITICAL ZONE, AND THE ANTHROPOCENE

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The great intellectual fascination of pedology derives from its comparative study of the diversity of Earth's soil, its interdisciplinarity required to understand even a single soil, and the many ways in which soil interacts with the natural and cultural environment (Richter and Yaalon, 2012).

Not surprisingly, pedologists have been instrumental to the development of the interdisciplinary Earth science of the critical zone (Jordan et al. 2001; Lin and Wilding, 2005), the critical zone being defined as the life-supporting system of Earth's surficial terrestrial processes. As an integrated body, the Earth's critical zone ("a thing" in the words of W.E. Dietrich, personal communication) extends the conventional definition of ecosystem to include not only the atmosphere, climate, and foliar boundary layer down through the soil to the deepest zone of mineral weathering. Defined by its fluids, the critical zone spans the atmosphere to the deepest aquifers; defined by time, the critical zone spans all biological and geological time scales and history; defined by its slogan, the critical zone extends "from treetop to bedrock". Jordan et al. (2001) when coining the critical zone used the word "critical" for good reason to emphasize the growing concern about human influence on this life-supporting system (Latour 2014). It is no coincidence that at the same moment that a congruence exists in the core concepts of ecology's ecosystem and Earth sciences' critical zone (Richter and Billings 2015), our geological epoch may be renamed the Anthropocene (Waters et al., 2015).

We propose that a paradigm of Earth's critical zones is that of soil production (Figure 1), a brilliant but underutilized framework first proposed by Gilbert (1877). (Note that what Gilbert called "soil" was later called "regolith" (Merrill 1897), although in this piece and others (Richter and Markewitz, 1995), we follow the Gilbert tradition). Here, we suggest that the soil-production paradigm can provide new perspectives of Earth's systems for ecosystem ecologists, critical zone scientists, and pedologists alike. We describe two examples of soil production at the Calhoun Critical Zone Observatory, a 70-year old research station in the Southern Piedmont of North America, a site that provides special insights into these critical zone issues, both over geologic history and during the Anthropocene itself. The first example is a residual soil and weathering profile produced directly from granitic gneiss below, a profile that includes fractured bedrock, saprolite, and argillic Bt horizons; the second example is a profile derived from transported paleo- colluvium from materials previously weathered in place. The comparison of residual and transported materials helps us understand how all soil state factors of climate, biota, geologic substrate, and geomorphology are dynamic over a soil's lifetime. We conclude by considering the role of human forcings as a dynamic and overwhelming new state factor in the Anthropocene (Dudal, 2001, Richter and Yaalon, 2012).

The soil production paradigm

In 1877, Gilbert stated with wonder, "Over nearly the whole of the earth's surface, there is a soil, and wherever this exists we know that conditions are more favorable to weathering than to transportation." Gilbert had realized a fundamental attribute of the planet, that across nearly all landscapes from the tundra to the tropics, weathering's production of soil particles and solutes (W) outpaces transport-related losses via erosion and dissolution (T). The Earth thus soil accumulates (Figure 1). Even in most naturally erosive environments, W keeps pace with T, and soil profiles may be thin but they accumulate. Given liquid water and biogeochemical weathering agents, W liberates mineral particles and inorganic solutes; T removes a fraction of those products but soils accumulate the remainder.

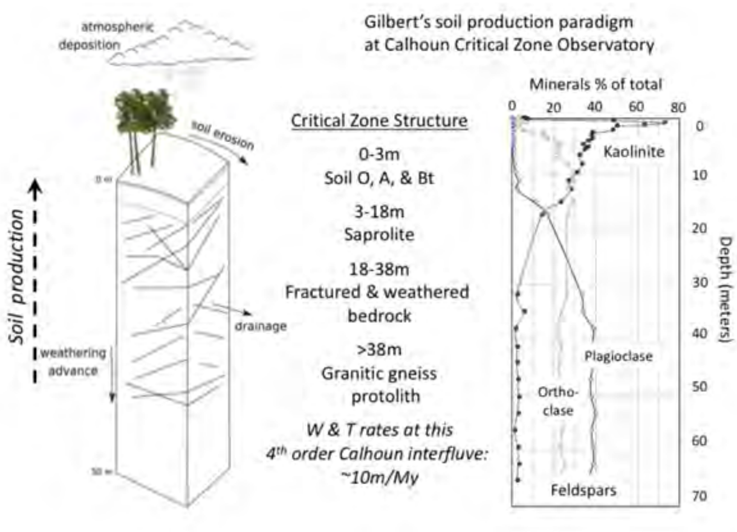

Figure 1. Diagram of Gilbert's soil production treadmill of W > T with structure, mineral, and rate details from a residual soil-weathering profile at Calhoun CZO (Bacon et al. 2012).

The dynamism of all soil state factors

At the Calhoun Critical Zone Observatory, many soil and weathering profiles have formed over several million years, and on sites that are geomorphically stable, soil accumulates in residual profiles that are 10s of meters deep (Richter and Markewitz, 1995, 2001; Bacon et al. 2012, St. Clair et al. 2016). One upland soil-weathering profile that is studied in detail has formed on nearly level terrane and has unweathered protolith below 38 m, fractured and weathered granitic bedrock between 38 to 18 m, saprolite C horizon from 18 to 3 m, and a well recognizable Ultisol with Bt, E, and A horizons in the upper 3 m. Plagioclase which composes ~38% by mass of the parent rock, weathers completely to kaolinite between 38 and 12 m; the primary mineral orthoclase weathers to form more kaolinite between about 10 to 1 m (Figure 1). Rates of weathering and transport are are on the order of 10m per million years, and the ^{10}Be residence time of the profile is at least 2 to 3 million years old (Bacon et al. 2012).

Viewed from the soil production paradigm, weathering in this residual profile has liberated inorganic particles (mainly quartz and feldspars) from the granitic gneiss at a more rapid rate than erosion and dissolution transport has been able to remove them. Remarkably, transport is dominated by dissolution rather than erosion, and nearly all feldspars have been dissolved and reformed as kaolinite by the time the soil particles arrive at the soil's surface to become part of the active root zone and are finally subject to erosion. Given the long residence time of the profile, the rate of soil production has experienced many significant changes in climatic and biotic forcings.

The soil production paradigm thus describes the treadmill on which mineral particles liberated from underlying geologic substrate are subject to biogeochemical processes of acid dissolution and hydrolysis on their ride to the soil surface. The mineral particles that compose the A and B horizons are survivors in the soil production system.

An Ultisol profile derived from ancient colluvium has been recently sampled and is used here to contrast with the residual profile described above. The second profile gives us an appreciation for the dynamic nature of landscape evolution and of all soil-state factors (not just climate and biota), and of the fact that most soils are now understood to be polygenetic. The second profile is also in the uplands and in fact lies <100m horizontal from the upper elevations of the contemporary landscape. The A, E, and Bt horizons of the soil profile developed in >5-m of colluvium that lacks rock fabric structure and which is completely exhausted of its original plagioclase. What is more, the colluvium buries a 2-m thick sandy layer with 14C-dead charcoal and wood fragments of unknown age, and this organic matter overlies a saprolite of unknown depth. A granitic gneiss is the ultimate parent below the saprolite. We hypothesize the organic deposits, many dozens of which have been identified across the region, to be at least 100s of thousands of years in age. Given the organic deposits and the age of the system, the contemporary Ultisol has formed in a colluvium that is much reduced in thickness due to erosion and dissolution. The profile has many wonderful mysteries, especially that it clearly indicates that the Piedmont is old enough to have had paleo-landscapes of unknown ages.

Viewed with the soil production paradigm, this colluvially derived Ultisol is related to the residual Ultisol profile of Figure 1, but it also has many contrasts. Whereas the first profile is derived directly from the weathering bedrock below, the second profile is derived from colluvium and illustrates clearly that soil production is not only controlled by the dynamic state factors of climate and biota but also the dynamic state factors of geomorphology and geologic substrata. Many soils have lifetimes sufficiently long that the parent materials that feed via Gilbert's soil production treadmill the soil's C, B, E, and A horizons *change* over soil time. In this ancient landscape, geomorphology and even the geologic substrates are clearly seen to be highly dynamic through time.

The polygenetic wave of human forcings

A major soil problem for the Anthropocene is that human activities are accelerating T relative to W, a shift that has enormous consequences for soils, ecosystems, water, the atmosphere, and the critical zone. In the Anthropocene, humanity has become the Earth's primary geomorphic agent (Hooke 2000), and natural soil profiles are disappearing rapidly (Amundson et al. 2003; Galbraith, 2006). Understanding how contemporary soils evolve as human-natural bodies is as important to pedology today as was the evolution of soils as natural bodies first articulated by Hilgard, Darwin, and Dokuschaev in the 19th century (Yaalon and Yaron, 1965). Recognizing humanity as "a fully fledged factor of soil formation" (Dudal et al., 2002) not only enriches pedology, but reinforces the vital role to be played by soil science in resource and environmental problem solving of the 21st century (Grunwald et al., 2011).

At the Calhoun CZO for example, farming has accelerated T via erosion over about 150 years (1800 to 1950), removed more than 15-cm of soil from the Piedmont region's crop fields, pastures, and gullies (Trimble, 2008). Because Piedmont uplands exceed bottomlands by about 10:1 in area, the legacy sediment deposits (James 2014) have entierely transformed Piedmont valley morphology and floodplain functioning. The novel legacy-sediment soils often amount to a meter or more in depth and are forming in mixtures of eroded A, B, and C horizons materials that have been lost from the uplands. Such human forcings are taking pedology well outside our previous experience with soil as a natural body, given our impact on the balance of T and W. As our land uses are transforming the physical, chemical, and biological properties and processes of soils across the landscape, soil scientists are challenged to develop a pedology with broad purview and decades' time scale that can fully support the science and managment of soils, ecosystems, and critical zones as well. How challenging for pedology that the contemporary polygenetic wave of human forcing involves new climates, biota, geomorphologies, *and* parent materials (Richter and Yaalon 2012).

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Keynote
Karen Vancampenhout

THE WAYS OF THE DEAD: HOW ECOSYSTEMS HANDLE THEIR ORGANIC MATTER

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As the largest terrestrial carbon reservoir, soils play a crucial role in the global carbon cycle and in many ecosystem services. But exactly how they manage to retain such massive amounts of organic carbon for such a long time, remains one of the great enigmas of soil science. Ever since the traditional views of large, chemically recalcitrant super molecules were refuted, theories on soil organic carbon stabilisation focus on physical protection of small biomolecules against decay in the soil, as association to clay minerals or inclusion in aggregates make molecules inaccessible for micro-organisms. The chemical composition or quality of the carbon input is now regarded as less relevant or even obsolete. Despite the shift in paradigm, current conceptual models on soil carbon resistance rarely differentiate between ecosystems, soil types or soil horizons. The aim of this contribution is to question this 'one model fits all' approach, as the relevance of different stabilising mechanisms may vary depending on the geo-environmental context and species involved. Indeed, through evolution ecosystems adapt to the constraints of their environment and develop traits or behaviours to optimally cope with limitations. There is no reason to assume that their carbon decomposition strategies have not evolved accordingly, and that the processes ruling the ways of the dead are just as diverse as those of the living.

In terms of soil (carbon) research, there is a considerable historical bias towards temperate regions with well buffered or agricultural soils, near major research stations and universities. In such soils, there is indeed enough catabolic power to break down even the toughest chemical bonds and physical protection from microbial decay is the dominant stabilizing mechanism. Far less is known about the functionality of carbon cycles in more challenging conditions: shortages in oxygen or nutrients for instance may hamper the decomposition of certain compounds. By comparing the soil organic carbon compositions of different ecosystems to their geochemical constraints, soil process domains, litter layers, above- and belowground community structures, fungal to bacterial ratio's, soil fauna and average turn-overs, clear patterns become evident suggesting that carbon cycles and the pathways and mechanisms of decomposing and stabilizing SOM vary across ecosystems world-wide and that interactions between contrasting edaphic factors and biological communities are not only diverse in nature but also exhibit non-linear behaviour. In poor systems, litter quality may play a much more important role than currently assumed, and may even become dominant.

To test the hypothesis that litter quality is a major determinant of the carbon cycle in certain ecosystems, we tested if a change in overstory species from mixed-deciduous to spruce would be sufficient to drive the carbon cycle down an alternative pathway. We selected a series of twin-plots along a lithological gradient in the old-growth deciduous forest of the Gaume (Southern Belgium). Although all soils of this vast forest complex are relatively acid, a difference in marl content of their parent material has kept some stands in the cation-exchange soil process domain while others were in the Al-exchange soil process domain prior to conversion. Each twin-plot consists of one observation square in a mixed forest stand and one in an adjacent patch of Norway spruce (Picea abies) plantation, allowing to study conversion effects and site effects independently. Our results show that – although pH changed by less than one unit upon conversion– it had profound effects on the below ground food web in terms of soil process domain, soil base availability, aluminium toxicity, soil fauna, litter layers and soil functional biodiversity. Soil carbon starts accumulating in the spruce stands, but this gain in carbon happens in the labile pools and a clear vertical decoupling between the litter layer, topsoil and subsoil is evidenced. Moreover, biomarkers in the soil organic matter suggest a shift in preferred carbon source. Hence, the shift in overstory species cascades through the soil carbon cycle, slowing it down into a different and possibly more primitive stable state, with clear differences in quantity and quality of soil carbon stocks.

Hence, we can conclude that there is an urgent need for a more dynamic, ecological view on carbon stabilization and carbon cycles, as governed by a multitude organisms that adapt to ecological thresholds and boundary conditions. This becomes particularly relevant in a context of global change, as anthropogenic disturbances could radically alter the carbon strategy of a particular ecosystem.

Parallel Session

Climate change 1

UNDERSTANDING THE RELATIONSHIP BETWEEN PLANT TRAITS AND NITROUS OXIDE EMISSIONS FROM GRASSLANDS SOILS

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Plant functional traits are increasingly used to understand how plants interact with the soil to control the provision of ecosystem services, including nutrient cycling and greenhouse gas regulation. In intensive grasslands, emissions of nitrous oxide (N_2O) from soil represent a major component of the greenhouse gas balance. However, a relationship between plant species and their associated traits and N_2O emissions has not yet been elucidated. Here we use a plant functional traits approach to investigate the relation between plant species and N_2O emissions from soils. We hypothesized that: 1) plants with exploitative traits are associated to lower N_2O emissions if soil N availability is high; and 2) plants with conservative traits supress N_2O emissions if soil N availability is low. This was tested in a greenhouse experiment using monocultures of six grasses with contrasting shoot and root traits, growing across a gradient of soil N availability. We found that exploitative species lowered N_2O emissions for all levels of N availability, produced higher biomass and larger N uptake. Consequently, acquisitive species had on average c. 90% lower N_2O emissions per unit of N uptake than conservative species ($P < 0.05$). We also found that specific leaf area and root length density were crucial traits modulating the effects of plants on N_2O emission and biomass productivity. Our results point the way to understand the mechanisms through which plants control N_2O emissions, and thereby to develop productive grasslands that contribute to climate change mitigation.

CLIMATE WARMING AND SOIL BIODIVERSITY: HOW AND WHEN TROPHIC INTERACTIONS MATTER!

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Climate warming poses a serious threat to biodiversity both at local and regional scales. However, our understanding of which ecological mechanisms mediate the warming effects on species diversity is still limited. This, in particular, is even less explored for soil organisms, which forms a substantial share of terrestrial biodiversity on Earth. Here, I aim to present results of both laboratory and field experiments to demonstrate the crucial roles of trophic interactions in warmed environments for determining species diversity at local scales. From a lab study, I demonstrate how greater predation alters the competitive interaction between the coexisting prey species in warmer environment, leading to a competitive exclusion of a prey species. From a field study, I show that warming-induced decline in predators promotes the diversity of prey species; however, with a greater taxonomic redundancy. These results are based on litter micro-arthropods and free-living soil nematodes. These findings extend our understanding of how warming-induced changes in trophic interactions are pivotal in determining biodiversity at local scales.

IMPACT ON TERRESTRIAL EXPOSURES FROM DUST ELEMENTS AND DUST EVENT FREQUENCY

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Dust events are potentially an important feedback factor to climate change and anthropogenic activities. Dust trajectories can be observed over large distances from the source areas to the deposition locations. The terrestrial Earth surfaces have been constantly exposed throughout their evolutionary time to dust elements, from both local and regional sources.

The past decades, south-western and western provinces of Iran are heavily affected by dust depositions. The effects of climate change, along with escalating anthropogenic activities in marshland, plain, and semi-arid regions nearby, are exposing the atmosphere to an increasing amount of dust materials.

The principle objective is therefore to provide information of elemental composition of dust particles deposited on the surface and suspended in the air.

The elements abundance in dust from the gauges in compare with guidelines, from World Health Organization (WHO), Agency of Toxic Substances and Disease Registry (ATSDR and OSHA), US environment Protection Agency (US.EPA), and European Union, were classified in this research area.

Different levels of elements will well been discussed based on key indicating elements with associated sources regenerated from dust deposition areas. Acid digestion (HCl:HNO3) using Aqua (ISO/DIS 17294-2:2014 conc.1:50) were employed for the total elemental analysis. The metal concentration and signal of elements, for Be, Na, Mg, Al, Si, K, Ca, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Sr, Cd, Ba, and Pb, were determined using inductively coupled plasma mass spectrometry (ICP- MS).

The association of daily data recorded from dust events frequency (DEF), which was based on its reduction of the visibility and standard for (<1000m visibility and PM2.5) together with results from ICP-MS analyses will be discussed. So a high correlation indicates a warning that might need to improve attention over the impact of dust events.

Keywords: Dust; Soil; Elements profile; ICP-MS; Trace elements.

SOIL CARBON AND NITROGEN STOCKS OF FOREST ISLANDS OF WEST AFRICA

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The biogeochemical mechanisms underlying the ‘forest island’ phenomenon in open savanna landscapes in West Africa remain critically under investigated despite the potential of utilizing such information in community carbon offset programs in the era of climate change. In this study, we report carbon and nitrogen stocks of nine forest islands across a range of landscapes in three West African countries of Ghana, Nigeria and Burkina Faso. Soils were sampled in each forest island using stratified random sampling technique at half canopy radius from tree trunks (T) and at half the maximum distance between two adjacent trees (G). Comparisons between the forest islands and adjacent managed farmlands were made. Soil carbon stock of the forest islands ranged from 9.90 to 45.47 Mg ha^{-1} at 0-5 cm depth and from 17.59 to 273.61 Mg ha^{-1} at 0-30 cm depth across all sites in all three countries. The corresponding soil N stock of the forest islands were in the ranges of 0.78 to 3.29 Mg ha^{-1} and 1.34 to 19.75 Mg ha^{-1}. The C and N stocks of the adjacent farmlands were markedly lower than that of the forest islands. These respectively ranged from 2.51 to 8.60 Mg C ha^{-1} and 0.22 to 0.78 Mg N ha^{-1} across all sites at the 0-5 cm depth. Values ranging from 11.89 to 56.64 Mg C ha^{-1} and 1.03 to 5.03 Mg N ha^{-1} were observed at the 0-30 cm depth. Results showed higher distribution of C and N at T than at G positions. Soil total C and N concentrations of the forest islands varied from 2.34 to 10.37% and 0.17 to 0.75%, respectively across all sites at the 0-5 cm depth which were remarkably higher than average values characteristic of West African soils. The study has established the potential of forest islands as huge carbon sinks for climate change mitigation in Africa.

SEQUESTRATION OF ATMOSPHERIC CARBON DIOXIDE AS INORGANIC CARBON IN THE UNSATURATED ZONE UNDER SEMI-ARID FORESTS

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Inorganic carbon, in the form of allogenic (transported) and pedogenic (soil) carbonates in semi-arid soils, may comprise an important carbon sink. Carbon dioxide, CO_2, originating from the atmosphere and exhaled by tree roots into the soil, may be hydrated by soil water within the unsaturated zone (USZ) of semi-arid soils to produce the carbonic acid (H_2CO_3) solutes HCO_3^- bicarbonate and H^+ Hydrogen ion. This H^+ may then dissolve relict soil $CaCO_3$ carbonate (calcite), to release Ca^{+2} calcium cations and more HCO_3^- bicarbonate. When conditions allow, one mole of Ca^{+2} and two moles of HCO_3^- combine to precipitate one mole of calcite, and to release one mole of CO_2: $Ca^{+2} + 2HCO_3^- \rightarrow CaCO_{3\downarrow} + CO_{2\uparrow} + H_2O$. However, it has been claimed that such carbonates do not sequester significant amounts of present day atmospheric CO_2. The reasons given were that they originate in part from the pre-existing limestone; and that for every mole of calcite precipitated, one mole of CO_2 may be liberated to the atmosphere. It was argued that only if the Ca^{+2} cation is derived from a non-carbonate source can sequestration be assumed. We have tested these assumptions under field conditions at two semi-arid sites in Israel. We found that bicarbonate, originating from root exhalation, is depleted and is incorporated within the USZ as carbonates precipitate. Thus, a net sequestration of atmospheric CO_2 does occur under semi-arid forests. Moreover, most of the CO_2 liberated in the precipitation reaction may remain in the soil. And Ca^{+2} in the sediment may also be supplied from sources other than pre-existing calcite. Forestation can therefore augment pedogenic carbonate formation. By extrapolating our data globally, we suggest that worldwide semi-arid forests (existing and to be planted) may sequester 5-20% of the current annual anthropogenic increase of atmospheric carbon dioxide as pedogenic carbonate.

TRANSPARC: FOREST SOIL CARBON SIMULATION MODEL

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The TransparC forest soil carbon simulation model aims to demonstrate the slow, but yet dynamic character of the forest soil C balance to researchers, students and policy makers. The forest soil carbon simulator lumps new and old organic matter into one pool for each of six different depth segments. These can be fixed depth segments or soil horizons. The excel spreadsheet runs for 40 years and calculates annual changes in the soil carbon sink in t C ha^{-1}. Inputs are soil depth segments (cm), initial soil carbon content (% C), annual aboveground litter fall (g m^{-2}), root litter distribution (% of aboveground litter fall) and turnover rates (k, $year^{-1}$) for each depth segment.

Two important pedological processes in mineral forest soils, bioturbation by macrofauna (earthworms) and podzolisation are included, allowing transfer of SOC between the forest floor and mineral soil layers.

Four common forested soil types in Denmark are presented as cases using data from the SINKS resampling study (1990 and 2008-10) of the National 7 x 7 km Nitrate monitoring grid. In the case study model runs decomposition rates (k, $year^{-1}$) were adjusted manually in the spreadsheet to fit observed change in C concentration over 18 years. The cases represent classes of subsoil texture and initial topsoil carbon content (sandy: 1.3%C and 2.6% C, loamy: 2.8% C and organic: 43%C).

The SOC stock changes were sensitive to the uncertainty of 1) aboveground litter and root litter inputs (-10%) changing C sink rates by -0.16 to -0.24 t C ha^{-1} yr^{-1}), 2) the turnover rate (+10%) of soil organic matter in mineral topsoil (-0.03 to -0.1 t C ha^{-1} yr^{-1}), and 3) earthworms (+5 pct points removed from ff to mineral soil, -0.001 to +0.05 t C ha^{-1} yr^{-1}).

The TransparC model with documentation can be downloaded from http://bit.ly/2oPIHlV

Parallel Session

Climate change 2

MODELLING SOIL ORGANIC CARBON FOLLOWING LAND-USE CHANGE TO BRAZILIAN SUGARCANE

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Sugarcane (Saccharum spp.) is a common bioenergy crop due to its large biomass production and high sugar content, from which ethanol can be produced and used in place of fossil fuels for transport, thereby providing benefits for greenhouse gases.

Brazil is currently the largest producer of sugarcane and the area currently cultivated with sugarcane is undergoing significant expansion due to the growing demand for bioethanol, driven by environmental, geopolitical and economic issues. This is considered one of the main causes of land-use change in the central-southern region and it has raised concerns about the potential environmental impacts of land-use change in Brazil. Therefore, it is necessary to investigate the effects of land-use change on soil carbon sequestration.

The ECOSSE model was developed to simulate soil carbon dynamics and greenhouse gases emissions in mineral and organic soils. It has been successfully applied to estimate the effects of land-use changes to bioenergy crops, such as Miscanthus and Willow, in the United Kingdom and could therefore be a useful tool to study the effect of sugarcane plantations in Brazil.

Here we parameterise and evaluate the ECOSSE model for its ability to simulate soil carbon under sugarcane plantations. We apply the model on selected Brazilian sites and investigate the effect of land-use change to sugarcane on carbon storage.

The results of the present work revealed a good correlation between modelled and measured soil carbon and soil carbon change after transition to sugarcane at 0-100 cm soil depth. Site measurements and model simulations indicated that converting pastures to sugarcane will lead to soil carbon losses, whereas the substitution of annual crops will result in soil carbon accumulation.

This work provides confidence for using ECOSSE for quantitatively predicting the impacts of future land-use change to sugarcane, at site level, as well as at national level.

EFFECT OF MANURE AND FERTILIZER APPLICATION ON BELOWGROUND CARBON COMPONENT AND CARBON EMISSION IN CORN FIELD

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The objective of this study is to find the effect of manure and fertilizer on microbial biomass and carbon emission in corn field in Southern Hokkaido, Japan. Mixed manure and chemical fertilizer application (MF) and fertilizer only (F) plots were established at Livestock farm of Niikapu station, National Livestock Breeding Center, Shin-Hidaka city. Aboveground net primary production (ANPP) and belowground net primary production of plant root ($BNPP_{root}$) were observed in each management season. Soil sample 5 cm depth was taken to determine microbial biomass carbon (MBC) using fumigation-extraction, and $BNPP_{MBC}$ was calculated as increment of MBC. MBC was significantly correlated with soil temperature negatively, and soil pH and soil moisture content positively ($p<0.05$). Correction of acidity and maintain suitable soil moisture are significant to feed microbial biomass. There was no significant difference of ANPP and $BNPP_{root}$ between F and MF plots, indicating that manure application did not influence corn production. $BNPP_{MBC}$ was also not significantly different between F and MF plots. But $BNPP_{root}$ increased after growing season, while $BNPP_{root}$ increased during the growing season.

Keywords: belowground carbon, carbon emission, fertilizer, manure, microbial biomass carbon

DO CACAO AGROFOREST MAINTAIN SOIL CARBON STOCK?

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Forest conversion into an intensive agricultural land use lead to the change of structure and land composition that decrease in carbon stock (soil organic matter/SOM). However, tree diversity and population in cacao agroforest may increase carbon sequestration and slow SOM degradation. The objective of this study was evaluating soil contribution as a carbon sequester in cacao-based agroforestry compared to other systems in Konawe District, Southeast Sulawesi, Indonesia. We compared five land use systems: degraded forest(DF), cacao-complex agroforestry(CAF) combined with fruit trees as a shaded, cacao-simple agroforestry(SAF), monoculture cacao(CM), and annual crops(CR). Carbon stock were estimated using the RaCSA (Rapid Carbon Stock Appraisal) protocol, assessing five carbon pools (trees, understorey, necromass, litter and soil organic carbon). Total C stock was significantly higher in DF(275 Mg ha^{-1}) followed by CAF, SAF, CM and CR(85, 75, 56, and 40 Mg ha^{-1}). The belowground C Stock(roots and soil organic matter) contributed 15% of the total in DF, 38% in CAF, and 52% and 57% in SAF and CM, respectively. The conversion of DF to intensive crops lead to decrease on soil C about 1.2 Mg ha^{-1}, whereas converting into cacao based agroforestry decrease 0.4 Mg C ha^{-1}. The average of soil carbon stocks in depth of 0-10cm, 10-20cm, and 20-30cm were 14.2 Mg ha^{-1}, 12.4 Mg ha^{-1} and 10 Mg ha^{-1} respectively. The top soil had a higher carbon stock, however the number was 50% lower compared to the average of agroforestry systems in tropics. This indicate that the possibility of soil carbon stock degradation is getting bigger in few years ahead if there are no management improvement. However, increasing the tree diversity and population in cacao agroforest can provide various organic matter input in order to maintain soil organic carbon, mitigating carbon emission, and increasing the resilience in the face of climate change.

SENSITIVITY OF SOIL ORGANIC MATTER DECOMPOSITION OF BIOCHAR-AMENDED SOIL TO WARMING

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Soil carbon decomposition is sensitivity to changes in the temperature. The addition of biochar may change the temperature sensitivity of soil organic matter. Biochar is the charcoal deliberatively produced to be applied in the soil. Due to the carbonization process, biochar is chemical recalcitrance, and more resistant to microbial degradation than ordinary soil organic carbon. However, due to its chemical recalcitrance biochar-amended soils may be more temperature dependent. The temperature dependence of biochar decomposition rate is not clear yet. Here, we investigated the temperature sensitivity of two types of soil to the addition of different rates of biochar (0; 6.25; 12.5 and 25 Mg ha-1). Biochar-amended soil treatments and their controls (soil only) were incubated at constant temperatures 20, 30 and 40ºC. The cumulative C-CO2 efflux per unit of C from 144-day laboratory incubation were used as a proxy of change in respiration rate and C stability. Our results show that: (i) in the short-term, the addition of biochar increased the amount of soil organic carbon; (ii) soil organic carbon decomposition in biochar-amended soils occurred fast in the Oxisol when temperature increased from 20 to 40ºC and in the Entisol when temperature raised from 20 to 30ºC; (iii) the absent of response pattern between biochar rates and temperature increasing indicated that other mechanisms than temperature sensitivity of recalcitrant C may be playing a role. We conclude that under warming conditions the potential of biochar-amended soils to sequester carbon is reduced.

SOIL CARBON ASSESSMENT FOR CLIMATE CHANGE MITIGATION IN THE NETHERLANDS

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The European Commission proposes to include the land use sector into the EU 2030 climate and energy framework. Accounting on managed cropland and grassland would become obligatory for EU member states. This offers the possibility to compensate emissions in other sectors by sequestrating carbon in or reducing emissions from soils, but also requires adjustment of land management policies. A countrywide assessment that quantifies current soil carbon emissions and removals and the potential for mitigation becomes of fundamental importance. However, few studies have evaluated the net gain of such policy measures at a national level, taking into account both carbon sequestration in mineral soils and reducing emissions from organic soils.

Here, we present an integrated soil carbon assessment for the Netherlands including current carbon stocks, emissions and mitigation potentials. Current carbon stocks were calculated for agricultural (0 – 30 cm), natural (0 – 30 cm) and peatland (up to 1 m) soils and carbon emissions from agricultural and peatlands were determined. The potential for carbon sequestration of mitigation measures for mineral soils was assessed by the RothC model. An empirical model was used to estimate the effect of water management practices on carbon emissions from peat soils.

The total amount of carbon sequestration in mineral soils was estimated at 1 Mton CO_2 per year in agricultural land. In addition, measures to reduce emissions from organic soils, among which infiltration via submerged drains and increase ditch water levels, can contribute about 1 Mton CO_2-eq as well. However, the required changes in land and water management depend on local soil properties, hydrological conditions and current management practices in the field. Maps with spatially-tailored land and water management practices are being developed, since they are considered a necessity for developing policy measures aimed at optimizing carbon sequestration in mineral soils and reducing emissions from organic soils.

TOWARDS A SAMPLING DESIGN FOR MONITORING GLOBAL SOIL ORGANIC CARBON STOCKS

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Accurate estimation of the global soil organic carbon (SOC) stock and temporal changes therein are of vital importance for climate-change studies. Most current assessments take a model-based approach to predict SOC spatially and aggregate point predictions to a global SOC stock estimate. Estimates of SOC stock dynamics are derived by repeating this procedure over time. Uncertainties associated with such estimates are rarely quantified, while they may be large compared to the estimate itself, especially for estimation of SOC stock change. Moreover, if uncertainties are quantified, they depend strongly on the model assumptions. Alternatively, estimates of global SOC stocks and changes therein may be obtained with design-based approaches, using statistical sampling theory. These methods have the important advantage that the estimates are model-free and accompanied by model-free accuracy measures. The main requirement is that the sampling locations are obtained using probability sampling and that all soil analyses are made in a standardised way. The aim of this study was to analyse whether design-based methods could produce sufficiently accurate estimates of SOC stock dynamics for realistic budgets. First, we derived the variance of global SOC stock (0-30 cm) point observations using global data from the ISRIC WoSIS database. Next we set the maximum acceptable standard error at 1.75 Gt C, which is 10% of the 5-year cumulative SOC stock increase targeted by the quatre pour mille initiative. We then computed the required sample size assuming simple random sampling. It turned out that 3000 soil observations are required to reach the accuracy threshold. Calculations for France and New South Wales further showed that this number can be more than halved if simple random sampling is replaced by a particular new kind of stratified random sampling. We conclude that from a technical point of view design-based estimation of global SOC stock dynamics is feasible. However, it is a considerable challenge to convince policy makers across the world to support and facilitate such project and to address all practical implementation issues.

Theme 3

Water resources

Keynote

Ryan Teuling

THE IMPACT OF SOIL MOISTURE AND LAND COVER ON ATMOSPHERIC CONDITIONS

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Recent summer extremes in Europe, including the summers of 2003, 2006 and 2015, have led to large socio-economic impacts. The impacts of such extremes on the hydrological cycle (including land use-specific impacts), as well as the impact of land surface-atmosphere feedbacks, are still poorly understood. Here, I present results from several recent studies on the impact of land cover, in particular forests, and soil moisture conditions on the European summer climate and cloud occurrence. In particular I will focus on the impact of land cover and soil moisture on surface energy exchange during heatwaves, the role of large-scale soil moisture anomalies and atmospheric boundary layer dynamics on temperature development during heatwaves and the role of forests in controlling the formation of convective clouds.

It has been hypothesized that during heatwaves, the absence of rainfall leads to reduced soil moisture, which in turn leads to a decrease in evapotranspiration. This decrease in evapotranspiration can contribute to high temperatures via so-called soil moisture-temperature coupling (Seneviratne et al., 2010). Analysis of FLUXNET data, however, revealed an absence of a strong soil moisture signal, and a considerably lower evaporative cooling over forest compared to grassland sites (Teuling et al., 2010). This is opposite to expectation given the generally deeper roots in forests. In a subsequent modeling study (Van Heerwaarden and Teuling, 2014), it was shown that the reduction in evapotranspiration can be explained by a strong response of stomatal opening to increased VPD, rather than a response to soil moisture. It should be noted that during typical drought situations in Central and Western Europe, the evaporation generally increases as a result of decreased cloud cover rather than decreases because of reduced soil moisture (Teuling et al., 2013).

At a larger scale and during extremely dry summers, soil moisture starts to be a limiting factor, and soil moisture-temperature coupling can amplify heatwaves. In a study on the origins of the 2003 and 2010 summer extremes in France and Russia, Miralles et al. (2014) found that the extreme temperatures could only be reproduced in a model where soil moisture limitation was taken into account. In addition to temporal soil moisture effects, land use-induced differences in fluxes can also induce spatial differences in atmospheric conditions. Such differences become apparent when conditions lead to cloud formation over one land use type but not over the other. In a recent study based on analysis of 10 years of METEOSAT satellite data, Teuling et al. (2017) found that over two large forest regions in France, more clouds are found than over the surrounding agricultural lands. This hints at an important role of forests in controlling regional climate. In the presentation, these and other recent insights on land use (Ellison et al., 2017) and soil moisture are discussed.

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Keynote

Yan Jin

COUPLED SOIL PHYSICAL AND BIOLOGICAL PROCESSES IN THE ROOT ZONE

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Increasing global population and consumption are placing unprecedented demand for food production (Foley et al., 2011). A key challenge to secure food supply is global water shortage, which are already limiting crop yield today and the limitation will intensify as agricultural activities expand to less fertile areas. Over 50% of population increase expected by 2050 will take place in Sub-Saharan Africa and another 30% in South and Southeast Asia – the same places projected to suffer most from climate change (Glassman, 2016). In the U.S., California's $54 billion agricultural industry has recently experienced the worse drought in 500 years. In 2014 alone, the state shed $2.2 billion and thousands of jobs from the agricultural sector due to drought, while water supplies, arable land, and soil integrity continued to decline (Glassman, 2016). The problem is global in scale for food markets and the associated economic growth (Timmusk et al., 2013). Therefore, developing novel solutions for crop growth under restricted water availability is of central significance.

Rhizosphere, a small volume of soil surrounding roots where large and diverse communities of bacteria reside, is a critical interface supporting the exchange of water and nutrients between plants and the associated soil environment. Enhancement of plant drought stress tolerance by PGPR has been increasingly documented (Rolli et al., 2014, Berg et al., 2013). However, investigations to date have been largely focused on PGPR-root/plant interactions that induce drought tolerance (Yang et al., 2009). Comparatively, much less is known about PGPR's role in mediating property changes in rhizospheric soil that may have impacts on plant drought stress tolerance. EPS released by PGPR possess large water holding capacity and are generally hydrophobic. EPS can influence soil water retention and hydraulic conductivity by modifying rhizospheric soil properties and consequently change plant water-use efficiency (Roberson and Firestone, 1992).

Enhancement of plant drought tolerance by plant growth promoting rhizobacteria (PGPR) has been increasingly documented in the literature. However, little is known about PGPR's role in mediating physiochemical and hydrological changes in rhizospheric soil that may impact plant drought tolerance.

In this study, we measured soil water retention characteristics, hydraulic conductivity, and evaporation in soils of various textures as influenced by a model PGPR (a *Bacillus subtilis* strain UD1022) using Hyprop©. We found that all PGPR-treated soils held more water, had reduced conductivity, and reduced evaporation rate compared to controls. While changes in evaporation due to PGPR addition occurred in all soils, how and to what extent they differed varied with soil texture. Scanning electron microscopy images show that while PGPR promoted aggregation in the pure sand, modification of soil capillarity and wettability likely dominated the PGPR effects in sandy, loam, and clay soils. The main reason for the observed changes is likely EPS production/biofilm formation. Neutron radiography images provide direct support on the differences of water distribution and evaporation between PGPR-treated soils and controls (Figure 1).

The long-term goal of our study is twofold: 1) to provide a more complete understanding of plant-soil-microbe interactions in the root zone and their influence on water retention and hydraulic properties and 2) to explore the application potential of using PGPR as an alternative (to plant genetic engineering and breeding), a soil-based solution, for reducing plant drought stress tolerance. This is a potential strategy for optimizing green water use efficiency by reducing evaporative loss thus increasing transpiration by plants. This optimization, as pointed out by Sposito (2013), will necessarily “require major campaigns in multidisciplinary basic research on positive pant-soil feedbacks that increase crop biomass by influencing the rhizosphere, through which 40% of the global freshwater passes annually”.

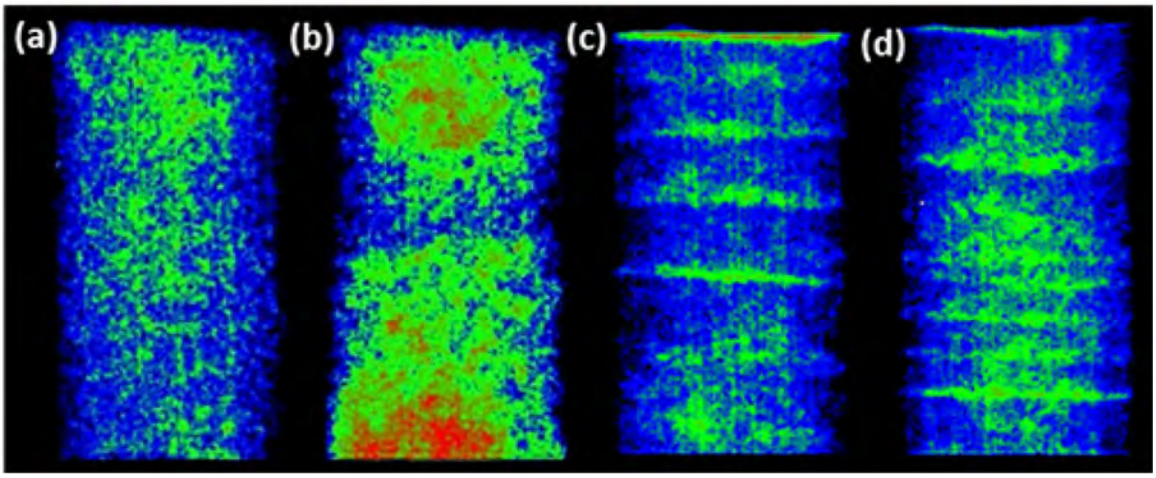

Figure. 1: Neutron radiography images of water retention and distribution of (a) sand, (b) sand-treated with UD1022, (c) soil, and (d) soil-treated with UD1022. Color red → green → blue indicates decreasing water content.

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Parallel Session

Water resources 1

MATCHING AGRICULTURAL FRESHWATER SUPPLY AND DEMAND: USING INDUSTRIAL AND DOMESTIC TREATED WASTEWATER FOR SUB-IRRIGATION PURPOSES

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Available groundwater sources for irrigation purposes are increasingly under pressure due to the regional coexistence of land use functions that are critical to groundwater levels or compete for available water. At the same time, treated wastewater from industries and domestic wastewater treatment plants are quickly discharged via surface waters towards sea. Exploitation of these freshwater sources may be an effective strategy to balance regional water supply and agricultural water demand. We present results of two pilot studies in drought sensitive regions in the Netherlands, concerning agricultural water supply through reuse of industrial and domestic treated wastewater. In these pilots, excess wastewater is delivered to the plant root zone through sub-irrigation by drainage systems.

Domestic wastewater treatment plants in the Netherlands produce annually 40-50mm freshwater. In a pilot project in the eastern part of the Netherlands, treated domestic wastewater is applied to a corn field by sub-irrigation, using a climate adaptive drainage system. The chemical composition of treated domestic wastewater is different from infiltrating excess rainfall water and natural groundwater. The bromide-chloride ratio and traces of pharmaceuticals in the treated wastewater are used as a tracer to describe water and solute transport in the soil system.

In the south of the Netherlands, the Bavaria Beer Brewery abstracts a large volume of groundwater and discharges treated wastewater to local surface water. At the same time, neighbouring farmers invest in sprinkler irrigation systems. Within a pilot study, a sub-irrigation system has been installed, with an inlet control basin for the treated wastewater to enter the drainage system. We combine both process-based modelling of the soil-plant-atmosphere system and field experiments to i) investigate the amount of water that needs to be and that can be sub-irrigated, and ii) quantify the effect on soil moisture availability and herewith reduced needs for aboveground irrigation.

THE WAHARA PROJECT: WATER HARVESTING FOR RAINFED AFRICA

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The vast majority of African farmers rely on rainfall for food production, but food production in Africa is under pressure by population growth and climate change. Three key challenges converge: 1) how will Africa feed its growing population? 2) how will African agriculture cope with climate change? 3) how to improve water security of rural Africans? Overcoming these challenges is the key to food security, and water harvesting can assist in this. The WAHARA project took a transdisciplinary approach to develop innovative, locally adapted water harvesting solutions with wider relevance for rainfed Africa. Water harvesting technologies play a key role in bringing about an urgently needed increase in agricultural productivity, and to improve food and water security in rural areas. Water harvesting technologies enhance water buffering capacity, contributing to the resilience of African drylands to climate variability and climate change, as well as to socio-economic changes such as population growth. To ensure the continental relevance of project results, research concentrated on four geographically dispersed study sites in Tunisia, Burkina Faso, Ethiopia and Zambia, covering diverse socio-economic conditions and a range from arid to sub-humid climates. The project emphasized: i) participatory technology design, i.e. selecting and adapting technologies that have synergies with existing farming systems and that are preferred by local stakeholders; ii) sustainable impact, i.e. technologies that combine multiple uses of water, green and blue water management, and integrated water and nutrient management; iii) integration and adaptability, i.e. paying attention to the generic lessons to be learned from local experiences, and developing guidelines on how technologies can be adapted to different conditions; and iv) learning and action, i.e. a strategy was developed to enable learning and action from successes achieved locally, to upscale within and across regions, promoting knowledge exchange at continental scale.

MAPPING WATER CONTENT OF UNSATURATED AGRICULTURAL SOILS USING GROUND-PENETRATING RADAR

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Soil water content from surface up to the root zone is important for agricultural crops. The conservative monitoring is based on point-measurement methods. Its time consuming and expensive. We suggest to use GPR (active remote-sensing tool) reflection and diffraction for subsurface spatial imaging and analysis of electromagnetic physical properties and water content. Combined with laboratory methods. This technique enables real-time and highly accurate evaluations of soils physical qualities in the field. To calculate subsurface moisture content, a soil model is required that includes texture, porosity, saturation, organic matter and effective electrical conductivity. We developed an innovative method that accurately measures spatial subsurface water content to a depth of 1.5 m in agricultural soils and applied it to two different unsaturated soil types from agricultural fields in Israel: loess soil type (Calcic haploxeralf), common in rural areas of southern Israel with about 30% clay, 30% silt and 40% sand, hamra soil type (Typic rhodoxeralf), common in rural areas of central Israel with about 10% clay, 5% silt and 85% sand. Combined field and laboratory measurements and develop model gave efficient determinations of spatial water content in the study fields. The environmentally friendly GPR system enabled non-destructive testing. The developed method for measuring moisture content in the laboratory enabled highly accurate interpretation and physical computing. Spatial soil moisture content to 1.5 m depth was determined with 1–5% accuracy, making our method useful for the design of irrigation plans for different interfaces.

Keywords: Ground-penetrating radar, water content, agriculture, soil, spatial mapping, active remote sensing

RETENTION OF LEAD AND ARSENIC IN CAJUN PRAIRIE SOILS OF LOUISIANA

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The vanishing Cajun Prairies of southwestern Louisiana are potential depositories of pollutants that may release lead (Pb) and arsenic (As) into the soil. Two restored prairies–Louisiana State University at Eunice (LSUE) and the Cajun Prairie Restoration Project (CPRP) in Eunice–and one remnant prairie (Estherwood) were investigated for their capacities to retain lead and arsenic. Soil samples from three different depths (0-10, 10-20 and 20-30 cm) were taken from each prairie. In three separate leaching experiments, 8 g of soil samples were placed in the leaching funnels, and then (1) 15 ml of Pb treatment solutions, (2) 15 ml of As treatment solutions, and (3) 15 ml of a mixture of Pb+As treatment solution, were added to leach through the soils for 1320 minutes (22 hours). At 2,000 mg/L Pb treatment, lead in leachate was detected, whereas, at lower Pb treatment solutions, no lead was found in leachate indicating that all the lead was completely adsorbed by the soil. At 250 mg/L As treatment, arsenic in leachate was early detected with a concentration of three times higher than the concentration of Pb in leachate at 2,000 mg/L Pb treatment. All restored and remnant prairies retained more lead than arsenic when leached separately. We hypothesized that the soils would influence the precipitation of lead arsenate (PbHAsO4) on Pb+As treatment as the mixture leached through the soils, thus reducing the concentration of lead and arsenic in the leachate. Results from this experiment to test this hypothesis, and the implications of lead and arsenic leaching into the groundwater will be discussed.

BIODEGRADATION OF WATER TREATMENT ADDITIVES: TRANSFORMATION AND BYPRODUCT FORMATION, IMPACT OF BIOCIDE SHOCKDOSING AND SALINITY

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Cooling towers account for a significant part of the industrial fresh water uptake. Several treatment technologies like reverse osmosis, electrodialysis and membrane distillation are employed to facilitate the reuse of discharged brackish cooling tower water. Next to a moderate salinity of ± 5 g/L, cooling towers water also contains different water treatment chemicals as corrosion inhibitors, biocides and antiscalants that are used simultaneously to maintain optimal functioning of the water circuit. However, these water treatment chemicals hamper the optimal functioning of the treatment technologies by for instance membrane fouling. An interesting water pre-treatment option is the use of natural treatment systems like constructed wetlands (CWs). Biodegradation is one of the main contaminant removal mechanisms in CWs. However, the biodegradation potential of CWs for many of the water treatment chemicals is not well understood. In this study, the simultaneous biodegradation of different representative water treatment chemicals by a CW inoculum is explored. The representative water treatment chemicals consist of 1H-benzotriazole (corrosion inhibitor), DBNPA (biocide), glutaraldehyde (biocide), PEG (surfactant) and HEDP (antiscalant). The following questions are addressed:

- Does shock dosing with biocides affect the CW biodegradation potential for the target chemicals?
- What is the influence of different salinities on the biodegradation of the target chemicals?
- Which signature microbial transformation products are being produced by single target chemicals that can be used to monitor biodegradation in CW systems?
- Do possible transformation products show ecotoxicological effects?

Theme 4
Land functions

Keynote
Taru Sanden

SWEET SPOTS OF MULTIFUNCTIONALITY IN ARABLE SOILS

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Soils and the several functions, such as nutrient cycling and carbon storage, that they supply the society with are closely linked to numerous sustainable development goals (SDGs) from the United Nations, which was recently described in Keestra et al. (2016). Goal 13 "Climate Action", goal 15 "Life on Land" and goal 6 "Clean Water and Sanitation" are some of the most obvious ones connected to soil functions, however, fulfilling the goal 17 "Partnerships for the Goals" also calls for contribution from knowledge on soil functions. In arable soils, the challenge is to supply several soil functions simultaneously, such as producing food, feed, fibre and biofuels, while also optimising the habitat for biodiversity and sequestration of carbon (Schulte et al., 2014). Where the societal needs and soil multifunctionality are optimised, sweet spots of multifunctionality occur.

Agricultural long-term field experiments (LTEs) provide basis to evaluate long-term effects of different soil management on soil and crop attributes. They enable understanding of how for example soil tillage or crop rotations affect numerous soil functions as well as facilitate transfer of knowledge to farmers and policymakers. Sandén et al. (in prep.) evaluated data from 263 LTEs on the effect of crop rotation, catch crops/cover crops/green manure, no-tillage, non-inversion tillage and organic fertilisers on soil functions. They observed beneficial effects of organic fertilisers such as compost and farm yard manure on soil physical quality whereas no-tillage or non-inversion tillage had the opposite effect in terms of higher bulk density. Soil biological quality was enhanced by amendment of organic fertilisers and incorporation of crop residues. These two improved management practices may also be used by farmers to increase the soil organic matter contents of the soils. Effectiveness of an improved management practice largely depends on the inherent soil qualities, environmental zone and the cropping system of a particular farm (Sandén et al., in prep.). Several international initiatives, including Infrastructure for Analyses and Experimentation on Ecosystems (AnaEE) and International network to foster mitigation and agricultural greenhouse gases (MAGGnet), which coordinate LTEs exist. In order to maintain the existing LTEs, and preferably extend the networks, continuous funding is needed to investigate how agricultural systems respond to improved management practices. New scientific questions such as how to facilitate multifunctionality in agricultural soils could take advantage of existing LTE networks. This way, similar management practices could be investigated in different environmental zones and on different soils and their parent materials.

Individual soil functions such as nutrient recycling depend on a set of attributes of soil, environment and management (Schröder et al., 2016).

Nutrient cycling per se is dependent on several processes including the capacity to receive nutrients, to make and keep nutrients available to crops, to support the uptake of nutrients by crops as well as to support the successful removal of nutrients in harvested crops. Individual soil properties are important attributes to describe the nutrient cycling function, however, they need to be considered together with climatic and management attributes. Moreover, one soil property may simultaneously benefit one soil function while it causes drawbacks to another soil function. Nutrient cycling in terms of removal of nutrients in harvested crops may be hampered by incorporation of crop residues since the amounts of nutrients harvested to the society in the short-term are less. On the other hand, this improved management practice would benefit habitat provision by providing food for microorganisms and could contribute to increased carbon sequestration and enhanced water retention (Schröder et al., 2016). This calls for local, tailor-made solutions that are recommended by others as well. Bullock et al. (2017) proposes diversifying crops and livestock at a farm scale. At larger regional or global scales they stress the importance of cooperation and co-creation between farmers, advisors and researchers so that solutions such as stress-tolerant crops can be provided. In order to enhance one soil function, the support of another soil function may be needed. For example, to secure long-term production of biomass, biodiversity in terms of diversity in crop rotation must be kept in mind to enhance yield resilience (Gaudin et al., 2015). To identify, maintain and enlarge agricultural sweet spots of multifunctionality require multidisciplinary cooperation.

In summary, there are no silver bullets or one size fits all solutions to ensure multifunctionality. However, in order to act upon the UN Sustainable Development Goals, the sweet spots of multifunctionality in arable soils can be identified and improved. Locally tailored solutions for optimising two to three, but preferably more, soil functions simultaneously will create additional agricultural sweet spots. By monitoring and maintaining those sweet spots, as well as creating new ones by improved management practices, more ecosystem services can be provided by the various arable landscapes.

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Keynote

David Wall

THE MULTI-FUNCTIONALITY OF GRASSLANDS FOR DELIVERING SOIL BASED ECOSYSTEM SERVICES

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The global importance of grasslands is indicated by their extent; they comprise some 26% of total land area and 80% of agriculturally productive land. Grasslands provide the feed base for most grazing livestock systems and thus numerous high-quality foods, as well as other by-products. In order to manage these grasslands and land resources sustainably requires viewing our soil and land resource in its totality and managing the landscape with due recognition of its complex integrated nature. Implicit in this, is recognition of the variable intrinsic capacity of soils under different land uses and management practices to deliver soil functions to a greater or lesser extent simultaneously (Coyle et al., 2016). Agriculture today is faced with delivering increased primary productivity to meet the growing global demand for food security (O'Sullivan et al., 2015). At the same time, society expects that any emphasis placed on increasing food outputs is met with an equal emphasis on sustainability (Garnett and Godfray, 2012) particularly as historically the intensification of agriculture, although not always, has often been associated with deleterious impacts on the environment (O'Sullivan et al., 2015).

In response to the emerging demands on soil and land use, Schulte et al. (2014) propose the Functional Land Management (FLM) framework. This conceptual framework seeks to optimise both the agronomic and environmental returns from the land resource. Central to this framework is the concept that soils are multifunctional and that all soils deliver multiple functions simultaneously. The subset of ecosystem services that rely on soil and land use for their delivery are referred to as soil functions (Bouma, 2014) and were first described in the European Commission Thematic Strategy for Soil Protection (EC, 2006). This concept is underpinned at a local level by the functional capacity of soils and recognises that the soil resource through agricultural landscapes simultaneously provides several soil functions, beyond primary productivity that are critical to society as a whole.

There remains a strong need for the promotion and inclusion of soil functions in the development of land use and management policies (Adhikari and Hartemink, 2016). In this regard, FLM centralises soil functions and the multifunctional capacity of soils at the heart of the framework. FLM focuses on the soil functions that are delivered through agricultural landscapes of which five are included: 1) Primary productivity, 2) water purification, 3) carbon sequestration, 4) habitat for biodiversity and 5) Recycling of (external) nutrients/agro-chemicals (see Figure 1).

The ability of the grassland soils to deliver multiple soil functions simultaneously is being assessed under the SQUARE Project in Ireland. Within Ireland, Food Harvest 2020 and Food Wise 2025 objectives to intensify agriculture are coupled with greening objectives of the Common Agricultural Policy amongst other environmental policy and regulatory instruments e.g. WFD. Thus, any intensification of agriculture must be achieved in a sustainable manner. However, knowledge gaps exist in relation to both the threats and benefits of soil quality.

In particular, soil structural quality is one major threat within Ireland. Soil structure is a key factor that supports all soil functions and it is predominantly influenced by land use and management.

It is evident that 'soil quality' should always be evaluated in view of environmental aspects and managerial options. Soil properties, weather conditions or management decisions with a positive effect on a specific soil function may go hand in hand with other soil functions but may also conflict with them. Competing demands for soil properties are even more imminent when considering multiple soil functions next to one another. Consequently, evaluations and actions must be region-specific if not site-specific and concerted in such a way that all societal demands are met in an optimal way at the required spatial scale (Schroder et al., 2016). This paper discusses the multi-functionality of grasslands based on a national study of Irish grassland systems. Thye synergies and tradeoffs between these five soil functions will be discussed relative to different intrinsic soil properties and land and soil management practices.

Figure 1. Soil functions that are being assessed on grassland soils under the soil quality assessment and research (SQUARE) project in Ireland.

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Parallel Session

Land functions 1

THE CASCADE PROJECT - UNDERSTANDING AND PREVENTION OF SUDDEN ECOSYSTEM SHIFTS IN MEDITERRANEAN DRYLANDS

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Drylands cover about 31% of the European landmass, and are the home of around 25% of its population, thereby making the lives of a substantial part of the European population directly or indirectly dependent on the wellbeing of these drylands. Research done by the European Environmental Agency (EEA), shows that especially the area around the Mediterranean, that largely consists of dryland, is becoming dryer, hotter and more sensitive to shifts to a desertified state. For these reasons, effective management of drylands is becoming increasingly important in order to prevent drylands from experiencing such sudden ecosystem shifts. Sudden Ecosystem shifts are processes whereby the ecosystem state shifts from a healthy state to a degraded state. These shifts are often caused by external drivers additional to climate change, such as overgrazing, forest fires or land abandonment. The CASCADE project (2012-2017) focused on gaining insight in underlying processes in the soil, vegetation, biodiversity and ecosystem behaviour when dryland ecosystems are put under pressure. Three key questions were addressed: i) What are sudden ecosystem shifts in drylands and how do different pressures lead to such shifts? ii) What processes happen in the soil and vegetation during a sudden shift? iii) How can we manage vulnerable ecosystems better? The CASCADE project consortium has tried to answer these questions from the perspective of various disciplines: soil science, plant ecology (both practical as theoretical), soil biology, sociology, and economy. Early warning indicators, such as changes in vegetation patterns and increased soil erosion may indicate upcoming ecosystem shifts. From the project findings and modelling work for upscaling, management strategies for land managers have been developed that take into account most effective strategies regarding effective timing, combinations of plant species and most economic ways of implementation for both ecosystem degradation and restoration. The most important project findings for protecting and restoring European drylands are presented.

SOIL STRATEGIES FOR RESTORING LAND FUNCTIONALITY IN DEGRADED DRYLANDS

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Global environmental changes and other anthropogenic impacts are rapidly transforming the structure and functioning of ecosystems worldwide, and leading to extensive land degradation. Drylands, which are characterized by extreme temperatures, low and variable rainfall, and low soil fertility, are particularly sensitive to these changes. Developing cost-effective large-scale solutions to restore these landscapes becomes thus critical to preserve their biodiversity, functionality and sustainability. A series of glasshouse studies and field trials have conducted in the arid zone of Western Australia to advance our knowledge on soil limitations, and provide innovative solutions to restore functionality of degraded drylands in Australia and worldwide. In these studies, we assesed the effects of diverse soil substrates in combination with different doses of organic (plant-based) and inorganic amendments on i) morphological and ecophysiological characteristics of biodiverse plant communities; and ii) multiple soil functions connected to key ecosystem services, including carbon sequestration, nitrogen fixation, soil stability and microbial activity and diversity. These re-created soils included blends of original topsoil and alternative soil materials commonly used in restoration programs. Here, we summarize the latest results obtained from these broad studies, and propose recommendations for effective application of these methods in restoration programs.

METHODOLOGICAL CONSIDERATIONS IN THE STUDY OF SOIL STONINESS. A CASE-STUDY IN A MEDITERRANEAN IRRIGATED GRAVELLY SOIL

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Stoniness has a great influence on many soil parameters such as physical, thermal, or chemical properties. Whilst a plethora of studies have focused on the fine particles of the soil, much less attention has been paid to the coarser fraction and its influence. The aim of this work was to give a complete overview of the most important features for rock fragments quantification, and to develop a study specifically designed to evaluate different strategies of description and quantification of rock fragments, using an experimental irrigated field in the Ebro Basin (NE Spain). Two soil sampling methods (using an Edelman type auger and excavating soil pits) were compared. The rock fragment distribution and the influence of tillage was also evaluated. Then, a collection of photographs was used for assessing the validity of different automatized image processing methods. A correct quantification was only achieved when a representative elementary volume “REV” of the soil was sampled. The use of an Edelman type auger underestimated the coarse fraction around 50-60% of its true value. Two years of no-tillage did not affect the presence of rock fragments at the soil surface, compared to conventional ploughing, which was thought to increase fine earth moving downwards the soil profile to deeper soil layers. Geostatistical analyses were proven useful for assessing the variability of the sampling scheme, showing that sampling intervals in the field experiment could be performed at larger intervals than 15 m. The automatization of the rock fragment coverage estimation needs further development for decreasing differences with the reference method. Nevertheless, it seems clear that certain recommendation should be followed when taking pictures like avoiding shadows, plastic or crop residues, soils recently ploughed or soils with a matrix of a similar colour to rock fragments.

ENVIRONMENT-MANAGEMENT INTERACTIONS DRIVE SOIL-BASED AGRO-ECOSYSTEM CHARACTERISTICS IN A RURAL ANDEAN LANDSCAPE

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Rural landscapes are by definition contexts which are moulded by human-environment interactions. However, while a growing body of work aims to untangle these interactions few studies recognise the agricultural landscape as a complex socio-environmental context that both influences and is in-turn, shaped by farm management. In this study we aim to tease out some of these human-environment interactions by identifying some significant biophysical patterns that emerge from the heterogeneity of the landscape and assessing the influence of landuses and features on the agroecosystems. As hypothesised we find strong evidence for a number of significant patterns within the landscape that emerge as a result of a myriad of environmental (pedogenic e.g., climate, geomorphology) and management (e.g., historical and current land management) factors. These patterns are generally characterised by linear, exponential and quadratic relationships with many significant interactions between altitude, slope and landuses. We find that altitude is generally positively related to most soil chemical characteristics, in particular soil organic matter (SOM), total N and available P, as well as a number of macrofauna and vegetative related parameters. The effect of slope on the soil characteristics of the landscape suggests erosion is having a significant influence on the soil chemical and physical properties. Moreover, current and historical farm and land management appears to be acting in a synergistic fashion on many of these patterns given the asymmetric allocations of manure by farmers along the altitudinal gradient and the suspected longer-term use of the lower elevations of the landscape. We conclude that in the face of evidence for land degradation, in order to improve and potentially restore agroecosystem functioning in this typically heterogeneous landscape a more managed and targeted approach to land management and recovery is required than is currently foreseen.

SOIL HEALTH IN OIL PALM PLANTATIONS: MANAGING SOIL ORGANIC MATTER

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Oil palm plantations in Indonesia are generally located on acid soils like Ultisols, Oxisols and Inceptisols, with pH <5.0, low availability of P, high Al and Mn activity, low soil organic matter content and a topsoil that is easily compacted leading to high rates of surface runoff and erosion on slopes. Sub-soil conditions inhibit root development, making oil palm sensitive to dry periods, inducing male flowers and a loss of production later on. Although the crude palm oil (CPO) that leaves the mill has low nutrient contents, the fresh fruit bunches that are brought to the mill are rich in nutrients. Oil palm plantations usually apply high doses of N, P, K and Mg fertilizer, but plot-level use efficiencies are low and recycling of mill residue incomplete, especially where smallholder produce is used. We describe efforts to improve soil health by managing organic matter, earthworms and soil porosity, aimed at life-cycle soil improvement and efficient recycling. Case studies in Central Kalimantan and S.Sumatra started in 2010. Soil health initially declined compared to secondary forest, with effects on earthworm populations preceding bulk density and Corg. Subsequent recovery of Corg depended on soil texture, with differentiation of Corg relative to a texture-based Cref between the management zones around each palm. Due to loss of forest worms and invasion by agricultural worms active in topsoil only (*Pontoscolex*), subsoil porosity depends primarily on old root channels. A split-root experiment showed that subsoil-rooting by oil palm is not due to (absolute) Al toxicity, but to (relative) Al avoidance. Managing soil health requires a comprehensive approach to create a soil environment that can work as a whole to support plants growth and minimizing environmental impacts. Adding deeper rooted companion crops and trees to the system may be needed to maintain subsoil infiltration rates desirable for sustainability.

SUB SURFACE DRAINAGE- BOON TO COMMAND AREAS OF KARNATAKA FOR ENHANCING CROP PRODUCTION

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Generally soils will have some salts including essential plant nutrients for crops. If the salts are present in excess, they impair the growth and yield of crops and are called as "salt affected soils". However, these soils can be made productive through drainage and amendments. Hence, a study was taken in waterlogged and salt affected soils of Bhadra command of Karnataka state to install subsurface drainage to see the changes in soil properties, amount of salts removed and changes in crop yield.

After installing subsurface drains in problematic soils of Tyavangi village, rice crop was grown for two seasons by applying required quantity of amendments, manures and fertilizers. During the crop period leachate discharged from outlets was measured and analyzed for pH, EC and ESP, cations and anions. Soil samples and crop yield data were collected from each field to study changes in soil and crop yield.

Totally 1.26 million liters of leachate was discharged in to natural nala through 10 outlets of subsurface drains, through which totally 19.65 tons of salts were removed. Maximum quantity of cations removed was sodium (1.61 t) and anion removed was bicarbonate (9.13 t). The sub surface drainage has increased rice yield to an extent of 22.99% to 25.13% and application of gypsum in sodic soils has increased rice yield to an extent of 35.68% and 38.28% in 1st and 2nd year respectively.

The soil data after installation of subsurface drainage, clearly indicated a drastic reduction in pH from 8.52 to 7.98. Similarly, the mean ESP has reduced from 14.71 to 9.14 with highest value of 35.80 reduced to 9.28. The study clearly indicated that by installation of sub surface drainage in water logged and saline soils and, application of gypsum in sodic soils has resulted in increased rice yield through reclamation and improved fertility status of the soil.

Keywords: Subsurface drainage, salt affected soils, cation and anion discharge, soil properties, rice crop.

Parallel Session

Land functions 2

THE RECARE PROJECT: PREVENTING AND REMEDIATING DEGRADATION OF SOILS IN EUROPE THROUGH LAND CARE

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Although there is a large body of knowledge available on soil threats in Europe, this knowledge is fragmented and incomplete, in particular regarding the complexity and functioning of soil systems and their interaction with human activities. The main aim of the RECARE project is to develop effective prevention, remediation and restoration measures using an innovative trans-disciplinary approach, actively integrating and advancing knowledge of stakeholders and scientists in 17 Case Studies, covering a range of soil threats in different bio-physical and socio-economic environments across Europe. Within these Case Study sites, i) the current state of degradation and conservation will be assessed using a new methodology, based on the WOCAT mapping procedure, ii) impacts of degradation and conservation on soil functions and ecosystem services will be quantified in a harmonized, spatially explicit way, accounting for costs and benefits, and possible trade-offs, iii) prevention, remediation and restoration measures selected and implemented by stakeholders in a participatory process will be evaluated regarding efficacy, and iv) the applicability and impact of these measures at the European level will be assessed using a new integrated bio-physical and socio-economic model, accounting for land use dynamics as a result of for instance economic development and policies. Existing national and EU policies will be reviewed and compared to identify potential incoherence, contradictions and synergies. Policy messages will be formulated based on the Case Study results and their integration at European level. A comprehensive dissemination and communication strategy, including the development of a web-based Dissemination and Communication Hub, will accompany the other activities to ensure that project results are disseminated to a variety of stakeholders at the right time and in the appropriate formats to stimulate renewed care for European soils. The project results since the start of the project in November 2013 will be presented.

CHANGING PRESSURES ON SOILS – A FORESIGHT STUDY ON SOIL MANAGEMENT IN GERMANY

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Global trends in demand for biomass based food, feed, energy and fiber call for a sustainable intensification of agricultural production. From the perspective of sustaining soil functions, this implies the integration of soil productivity with the other soil functions and services. Soil management is the key to this integration. The proper anticipation of future opportunities and challenges for sustainable soil management requires an analysis of drivers and trends affecting soil management.

We made a literature review and conducted 19 interviews with experts on drivers and trends of soil management and their relevance for soil functions taking Germany as example of high technology agriculture. We identified two modes of future management changes: (1) Quantitative changes as part of a moderate intensification may challenge sustainable soil management. (2) Qualitative changes of soil management practices mainly present opportunities. The highlights are: We found the technological drivers with information and communication technology (ICT) and robotics offer opportunities for significant relieve of pressures on soils with higher precision in the short-term and smaller, lightweight machines in the long-term. While some of this may be realized for farm economic reasons, some of this potential, especially smaller-scaled field patterns with more transition zones, will only be realized if policy incentives will be set on this. Farmers may diversify crop rotations due to increased pest occurrence and decreased effectivity of pesticides, supported by a diversified demand of consumers and policy incentives. The inoculation of soil with microbes and natural enemies of pests are likely to become marketed as sustainable solutions for soils management and crop production. Their impact cannot yet be sufficiently anticipated. Practices may be reinforced by a behavioral trend towards sustainable soil management, which is driven by increasing awareness, knowledge, and consumer demand. This study delineates opportunities and challenges for sustainable soil management and intensification.

SOIL ECOLOGY AND ECOSYSTEM SERVICES OF DAIRY AND NATURE GRASSLANDS ON PEAT

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Peat wetlands are of major importance for ecosystem services such as carbon storage, water buffering and maintenance of biodiversity. However, drainage for dairy farming may lead to increased CO_2 emission, soil subsidence, societal costs and biodiversity losses. Solutions are sought in reducing drainage, adapting farming to wetter soils, and converting dairy grasslands to nature. We compared the soil ecology and related ecosystem services of twenty dairy and twenty nature grasslands on peat in the Netherlands. Soil abiotic and biotic parameters were measured (0-10 cm depth), with particular focus on the ecosystem services (i) grass production (soil fertility), (ii) mitigation of climate change (CO_2 emission), (iii) water buffering (water infiltration) and (iv) maintenance of biodiversity (soil faunal diversity).

The potential for grass production was higher in dairy than in nature grasslands. This was related to higher nutrient concentrations, pH and root densities. Potential N and C mineralization (CO_2 emission) were similar in dairy and nature grasslands. As the variation in these parameters was partly explained by soil water content, mineralization rates in the top soil appeared to be limited by moisture independent of land use type. Water infiltration rate was higher in dairy grasslands, and correlated with soil porosity. Earthworm abundance was also higher in dairy grasslands, as well as the mean soil faunal taxonomic richness per site. However, the total observed number of taxa per land use type (gamma diversity) was higher in nature grasslands. Our findings show that land use type strongly affects the ecosystem services of grasslands on peat soils.

ASSESSING SOIL STRUCTURAL QUALITY IN IRISH GRASSLAND SOILS

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Sustainable management is essential to support soil, which is a vital non-renewable resource, ensuring the viability of food and fibre production, nutrient cycling, carbon cycling and storage, filtration of water and a habitat for biodiversity. Soil structure is a key factor that supports all soil functions and it is predominantly influenced by land use and management. Recent research within the field of visual soil assessment has enabled a quick evaluation of soil structure by different land users. However, the scientific community often attribute the evaluation of soil structural quality to physical parameters, considered more objectives and measurable, such as bulk density (Bd) or particle size distribution.

The focus of our work is to assess soil structural quality through physical parameters and visual methods, and to relate that to soil functional quality. Importantly, land management needs to be appropriately studied to understand whether and how it drives soil structure quality and related functions. A land use intensity index (LUI) was built using management information collected through a farmer questionnaire on management practices. This detailed questionnaire was run at 38 grassland farms distributed in the five major agro-climatic regions of Ireland in order to cover all the common farming practices carried out in Irish grassland soils. The derived land use intensity index (LUI) was based upon three management intensity components: (i) intensity of Fertilisation (Fi), (ii) frequency of Mowing (Mi) and (iii) intensity of Livestock Grazing (Gi). A combined approach of visual evaluation methods and quantitative measurements was conducted. Initial findings indicate that the LUI components are efficient metrics of soil structure quality. Further development of visual evaluation methods and an in-field soil structure index have shown to facilitate rapid in-field assessment of a complex soil property and can support better-informed management decisions.

MODELING SOIL ORGANIC CARBON MANAGEMENT IN CROPFIELDS. INTRODUCTION OF A RESOURCE BASED INDICATOR TO ACCOUNT FOR REMEDIATION ACTIONS

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The growing demand for food and feed has put an increasing pressure on agriculture, with agricultural intensification as a direct response. Notwithstanding the higher productivity, intensive agriculture management entails many adverse environmental impacts such as land degradation including soil erosion, soil compaction, and soil organic carbon decline. The latter is worldwide considered as an environmental risk that compromises soil fertility and productivity. Farm management decisions can highly influence Soil Organic Carbon (SOC) concentrations and certain rotations can induce a shortage of SOC. If the SOC level is too low, specific measures such as catch crop cultivation or applying higher manure doses should be taken.

The goal is to introduce a framework to assess the long term ability to sustain future biomass production from a resource point of view (Area of Protection Natural Resources). The framework accounts for soil quality losses with a focus on the decrease of SOC stocks. The soil carbon model RothC is used to simulate the SOC evolution due to farm management. The extent to which correction measures are required to restore the SOC level to a reference level and to maintain that level, is a measure for the induced soil quality losses.

A resource accounting approach is used to find out whether investments in a better soil quality are rewarded. The efforts to improve and maintain the threshold of SOC are weighted against the obtained higher yield. The biomass productivity is estimated by the EU-Rotate_N model. Exergy units are used to enable a fair comparison between the resource consumption of the inputs and the desired outputs of crop production systems. The exergy concept is very useful as it is a quantifier for both the amount and quality of the material and energy flows. The developed concept is applied on a case study in Flanders.

ASSESSING CHANGES IN SOIL NUTRIENT STATUS IN RESPONSE TO DIFFERENT FOREST HARVESTING PRACTICES

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The substitution of biomass for fossil fuels in energy consumption is a measure to decrease the emission of greenhouse gases and thereby mitigate global warming. Over recent years, this has led to an increasing interest to use tree harvest residues as feedstock for bioenergy. An important concern related to removal of harvesting residues is, however, the potential adverse effects on soil fertility caused by an increased nutrient removal, relative to conventional stem-only harvesting. In the Netherlands this is a major concern, because we have many forests on nutrient poor sandy soils.

Here we report the results of a soil balance modelling approach assessing the change in forest soil nutrient status by comparing inputs of the nutrients phosphorus (P), calcium (Ca), magnesium (Mg) and potassium (K) by deposition and weathering with the outputs of those nutrients by tree harvesting and leaching, distinguishing stem-only harvesting and additional removal of tree tops and branches. Results are given for the whole of the Netherlands, distinguishing seven major tree species, seven soil types (various forms of sand, loam, clay and peat soils) and nine regions, with variations in atmospheric deposition of the nutrients. For each region-tree-soil combination we calculated the maximum amounts that can be harvested such that the output of the nutrients P, Ca, Mg and K is balanced with the inputs.

Results showed that at current harvesting rates, a negative nutrient balance is hardly calculated for the loamy to clayey soil types except for K, since K weathering in clay soils is generally limited and comparable to that in sandy soils. Nutrient depletion, however, mainly occurs in the sandy soils, particularly in P and K. Compared to K, the available P pool is, however, much larger and depletion of the P pool takes many rotations, even in case of harvesting stems, tree tops and branches on poor sandy soils.

We discuss the uncertainties when translating the results to an advisory system for forest harvesting.

ISRIC Session

Applications of soil data in global studies

THE USE OF SOILGRIDS TO PARAMETERIZE AND EVALUATE A GLOBAL SOC PROFILE MODEL

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The field of soil organic matter modelling has seen a paradigmatic shift with regard to which processes determine the long-term persistence of organic matter in soils. The interaction between microbial decomposition, association of organic matter with the soil mineral matrix and transport has been identified as a focal point for understanding the formation and turnover of soil organic matter. In global modelling studies the stabilization of organic matter on soil minerals has not been adequately addressed, but is essential for our understanding of the spatial distribution of soil organic carbon.

Here we use SoilGrids data for parameterizing and evaluating the vertically explicit SOM model COMISSION, coupled with the Earth System model JSBACH. In COMISSION we model organo-mineral association equivalent to a dynamic Langmuir sorption model. Plant- and microbe-derived dissolved organic carbon and dead microbial cell walls are assumed to form organo-mineral associations. The maximum organo-mineral association capacity was estimated based on the global distribution of clay + silt in SoilGrids.

We simulated SOC stocks in 15 layers including the six standard depths of SoilGrids. The COMISSION model reproduces spatial patterns of top 1m SOC stocks from SoilGrids reasonably well (r^2 = 0.51). Adjusting bulk densities in SoilGrids with the same bulk density to organic carbon content relationship that we use in COMISSION this correlation gets slightly higher (r^2 = 0.61). Global SOC stocks in COMISSION amount to 1345 Pg which is close to SOC stocks reported by HWSD and WISE30sec (both merged with NCSCD) of 1375 and 1457 Pg, respectively, but not SoilGrids_v0.5 SOC stocks of 2867 Pg (SOC stocks reported at approx. 1.88° x 1.89°). We also present ideas on a regularized upscaling of SOC stocks which would facilitate comparison with models regardless of the prescribed layer thicknesses.

ASSESSING THE GLOBAL POTENTIAL FOR SOIL CARBON SEQUESTRATION USING THE S-WORLD GLOBAL SOIL PROPERTY DATABASE

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Soil carbon sequestration is receiving increasing attention as a measure for climate change mitigation and the maintenance or increase of soil productivity. A range of different initiatives including climate smart landscapes, payments for environmental services, and the global 4 ‰ initiative promote carbon sequestration. All initiatives require an assessment of the carbon sequestration potential to target land management strategies in an effective manner. This work presents a spatially-explicit global assessment of the soils' capacity for soil carbon sequestration and the actual potential for soil carbon sequestration. The soils' capacity for soil carbon sequestration is determined by local biotic and abiotic conditions, those posing a critical maximum limit up to which soils can accumulate carbon. However, the actual potential for soil carbon sequestration is determined by current land use and soil conditions. For example, intensively managed agricultural areas and Fluvisols typically show a higher potential for carbon sequestration than natural areas and Arenosols.

This study embarks on the recently published S-World global soil property database that provides global, 30 arc-second maps for a range of different soil properties, including soil organic carbon (SOC) and soil depth, describing the actual soil conditions as well as natural soil conditions. In the analysis, S-World estimates the range that soil carbon and soil depth can have given a specific soil type, topography, and climatic conditions. This range can be interpreted as the 'window of opportunity' for each soil type, for each location on the earth's surface. In combination with land use data, the soil data provides us the current soil conditions. Knowing the window of opportunity of the soil conditions and the current SOC content, we derived a spatially-explicit assessment of the physical potential for soil carbon sequestration, at the global scale. The results indicate where soil carbon sequestration can be most effective and identify hotspots where measures are likely to be most effective.

THE GLOBALSOILMAP PROJECT

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The demand for global information on functional soil properties is high and has increased over time. The *GlobalSoilMap* consortium was established in response to such a soaring demand for up-to-date and relevant soil information. The majority of the data needed to produce *GlobalSoilMap* soil property maps will, at least for the first generation, come mainly from archived soil legacy data, which could include polygon soil maps and point pedon data, and from available co-variates such as climatic data, remote sensing information, geological data, and other forms of environmental information.

Procedures and methodologies to produce this information vary depending on the types and amount of available data, but all information meet the *GlobalSoilMap* standards and specifications. These specifications are the only specifications for a global soil information system to be derived using a consensus-based process. The *GlobalSoilMap* specifications do not prescribe the methods of prediction, because of diverse soil legacy data situations in various countries. However, a flow chart that outlines different models that can be applied. The estimation of uncertainties is a major challenge of this project.

Several countries have already released products according to the *GlobalSoilMap* specifications and the project is rejuvenating soil survey and mapping in many parts of the world. A huge effort of skill development has been undertaken and should be pursued. We believe that combining countries and worldwide predictions could lead to a first product completely meeting the *GlobalSoilMap* specifications by 2020, and that for this purpose both top-down and bottom up approaches are necessary and complementary. Indeed, combining local and global predictions should be the way forward both to enhance the quality of digital soil maps and their use, and to map the entire world.

TOWARDS GLOBAL SOIL DATA INTEROPERABILITY: GODAN SOIL DATA WG AND SOILML (OPEN) DATA EXCHANGE FORMAT

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Open soil data is becoming increasingly available through conventional data download and as web services to support, e.g. data mining and analytics. Soil data comes from multiple sources, is managed by many organisations, structured in different ways, provided in different formats and as a result is difficult and time-consuming to share and harmonise across agencies and geographic boundaries. This is a barrier for regional and global policy, who need better sharing of data for studies on e.g. sustainable land management, food security, climate change mitigation and soil-related indicators for the UN Sustainable Development Goals.

GODAN represents a global community of stakeholders who advocate for open data that is available, accessible and re-usable world-wide. The newly formed GODAN Soil Data Working Group promotes this by agreeing on a global soil information model including definitions (vocabularies) and standards. This will facilitate the provision of human and machine readable data to support global soil data use cases. The model is extensible for new datatypes and analytical methods. The common data exchange format, SoilML, will be based on a conceptual model that describes soil features like soil body, horizon, profile and related properties. The model will build upon the lessons learned developing ANZSoilML, SoilIEML, soil-INSPIRE, eSOTER, and ISO28258:2013. As a proof of concept the OGC SoilML Interoperability Experiment demonstrated that it was possible to achieve interoperability between soil information systems hosted in agencies in different countries.

The WG closely cooperates with members of the Global Soil Partnership, the IUSS Soil Information Standards WG, the Open Geospatial Consortium (OGC) Agriculture Domain WG and ISO-TC190 Soil Quality. On a practical level, the existence of a globally agreed conceptual model and related ways to encode data, supported by associated capacity building will advance the aspirations of GSP-P5, IUSS-SIS-WG and GODAN to increase global soil data exchange.

GLOBAL CZO AND LTER SITE DATA AND MODEL APPLICATION

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The development of numerical models that combine physical, biological and chemical processes is a general goal of the International Long Term Ecological Research network (ILTER) and Critical Zone Observatories (CZO). In collaboration with the ILTER, CZO and the Critical Zone Exploration Network (CZEN), the International Soil Modelling Consortium (ISMC) organized a survey to assess the current status and goal achievement of the networks modelling ambition. The survey was organized to identify pressing gaps in data availability in particular for development and evaluation of models representing processes in the Earth's critical zone. In the analysis of the survey results, we test two seemingly contradictory hypotheses:

1) we expect the majority of models being of a holistic/integrated character, comprehensive and of high complexity since the LTER/CZO sites provide comprehensive data sets;

2) on the other hand we expect that the more complex the model, the less measured data will be used. In other words, the more time invested in the model, the less in the data. Hence, we expected that the currently used complex Earth system models of the type land surface models do less frequently apply rich data sets; either maximally relying on existing (large scale covering) databases or falling back on already harmonized modelled data as this proves easier to 'handle' and to get models tuned and running.

Results of the survey tend to support the second hypothesis, indicating the still overwhelming need to improve Critical Zone process understanding and the weakness/challenge (remaining but little dared) of validation for the Earth system models that integrate the different processes operating in the Earths critical zone. Nevertheless, the survey does also highlight a general tendency to more integrated modelling of LTER/CZO sites, and gives indications for strengths and gaps of the gathered data.

MAPPING OF FERTILIZER RECOMMENDATIONS FOR MAJOR CROPS IN WEST AFRICA

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Site-specific fertilizer recommendations for major food crops in West Africa have been updated and mapped by ISRIC in collaboration with the International Fertilizer Development Centre (IFDC) and experts from the NARs of Benin, Burkina Faso and Ghana. The project served as a proof of concept and was carried out within the context of the West Africa Fertilizer Program (USAID WAFP) which *has been implemented over last five years in collaboration with* the Economic Community of West African States *(ECOWAS).* A tiered approach was applied which makes use of the soil property maps for Africa (SoilGrids) including the recently released maps of all macro, meso and most micro nutrients. The maps at a resolution of 250m were produced using soil analytical data from over 60,000 sample locations. In the first tier, QUEFTS was parameterised using georeferenced fertilizer trial data compiled from three countries and used to calculate and map crop nutrient uptake- and use efficiencies and corresponding fertilizer recommendations targeting spatially variable yield levels for millet, sorghum, maize, rice and cassava. These first tier maps were added to regional covariates to model and map the fertilizer recommendations, which had been interpreted and reported from the fertilizer trial data, in the second tier using machine learning. The site-specific fertilizer recommendations were spatially aggregated according to agro-ecological zones and nutrient clusters and these aggregates were expressed by probability distributions to quantify the (un)certainty of obtaining targeted crop responses. Herewith this (un)certainty is made function of mainly the spatial variability of soil nutrient contents. However the trial data show that this uncertainty, and response in general, is predominantly determined by the spatial as well as temporal variability of the nutrient gap, as limited by water supply. This latter variability is emperically not well modelled with QUEFTS and is insuffiently well reflected in the maps used for defining target yields. The proof of concept provides an operational framework for progressive and collaborative updating and upscaling of fertilizer recommendations across the region, adding value to additional adequate soil-crop data. The framework is preferably further improved by modelling of the nutrient gap.

UNDERTAINTY IN SOIL DATA AND IMPLICATIONS FOR GLOBAL GRIDDED CROP MODELLING

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Global Gridded Crop Models (GGCM) are widely used for estimating regional and global impacts of climate change on crop yields and agricultural externalities based on soil, climate, and management data. At the present standard resolution of 0.5°, typically only the most dominant soil derived from global soil datasets is used.

However, global soil data products such as the Harmonised World Soil Database v1.0. (HWSD) may provide a wide range of soils per grid cell at this level of aggregation. Running a global EPIC-based crop model for all available soil types per grid cell with maize as a representative crop and different intensification levels concerning nutrients and irrigation water supply shows that substantial uncertainty in yield estimates is introduced by the selection of soil types.

Especially at the low intensification end, yield estimates are highly sensitive to soils in supplying nutrients and water. Under rainfed conditions, the uncertainty introduced by the selection of soil types remains high at all levels of nutrient supply. Only elimination of nutrient and water limitations through management virtually eliminates the impact of soil data. This has also an effect on climate change impact estimates, which can differ substantially depending on which soil type was selected in each grid cell. At present, this suggests that uncertainty in soil data at coarse resolutions can only be addressed by simulating all or various contrasting soils per grid. A way forward may be the better identification of soil types actually cultivated in each grid cell based on high resolution land use data.

Another limitation in global soil data for crop modelling is the often lacking availability of hydrologic characteristics such as field capacity, which hence need to be determined by crop models themselves using a variety of methods. Including such parameters in global soil data may substantially reduce uncertainties relating to water supply, such as microbial processes besides plant growth itself.

ISRIC Special Event: Launch Soil Data Facility of the Global Soil Partnership

LAUNCH! ISRIC HOSTS SOIL DATA FACILITY FOR THE GLOBAL SOIL PARTNERSHIP

30 August, The Spot Bar, Orion, Wageningen Campus

We are happy to announce that ISRIC – World Soil Information has been elected to host the Soil Data Facility of the Global Soil Partnership!

ISRIC invites you for drinks & bites to celebrate the launch of the Soil Data Facility

Attendees will have the chance to learn how they can benefit from, support and add value to the Soil Data Facility, learn how ISRIC will take on their new role, what the objectives are of the Global Soil Partnership. We have a special guest reflect on the importance of soil data in the context of global issues. This special speaker will be announced soon!

About the Soil Data Facility and the Global Soil Partnership

On 20th June 2017 the Plenary Assembly of the Global Soil Partnership (GSP) selected ISRIC – World Soil Information to host the Soil Data Facility that will be developed as part of Pillar 4 of the partnership. This means that ISRIC will (i) contribute to the design of the Global Soil Information System, (ii) participate in capacity building programs and (iii) provide a system that integrates the national facilities into a global soil information system.

The Global Soil Partnership (http://www.fao.org/global-soil-partnership) was established in December 2012. Its mandate is to improve governance of the limited soil resources of the planet to guarantee agriculturally productive soils for a food secure world, as well as support other essential ecosystem services. For the GSP to achieve its mandate, they address 5 pillars of action to be implemented in collaboration with its regional soil partnerships.

Pillar 4 of the GSP addresses the development of a Global Soil Information System and requires the active participation and contribution of national soil information institutions. For this, an International Network of Soil Information Institutions (INSII) has been established (see figure below). ISRIC, in their new role of Soil Data Facility, will assist the INSII to build national and regional soil information systems and will integrate these by providing a central global soil information system.

ISRIC is proud to be trusted this important role by the Plenary Assembly of GSP and will continue to work closely together with the Pillar 4 Working Group and INSII to contribute to the a sustainable use of the global soil resources.

Theme 5

Biodiversity

Keynote

Gerlinde de Deyn

GLOBAL SOIL BIODIVERSITY: WHO, WHERE, WHY AND SO WHAT?

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At global scale soils are the most diverse habitats we know. Soil microbes and soil invertebrates are estimated to represent one third of all biodiversity on Earth. Not only are soil biota very diverse in numbers but also in the range of body sizes and functions they perform. As they live a hidden and quiet life in the soil they generally go unnoticed. Consequently the soil biota did not receive the attention they deserve given the key roles they play in ecosystem functioning. At the same time soils are being degraded across the globe at much faster rates that that new soils are being formed. We are thus losing soil biodiversity and the associated regulating and supporting functions of soils worldwide. The way to reverse this situation is to raise awareness across the board and now is the time to do so.

Despite the many essential services provided by life in the soil, soil biodiversity has been largely ignored in global and regional policies addressing land management, food security, climate change, loss of biodiversity and desertification. In order to show the growing scientific evidence that optimization of soil biodiversity is critical for sustainability, and for the successful implementation of the United Nations Sustainable Development Goals (SDGs), soil ecologists across the globe joint forces and created the first Global Soil Biodiversity (GSB) Atlas, in conjunction with the European Union Joint Research Centre. Here I will present the GSBAtlas which was released in 2016, to picture and discuss the major patterns and drivers of the distribution of soil biodiversity, the threats to soil biodiversity as well as the use of soil biodiversity to help and restore degraded soil and to improve sustainable use of soils.

Orgiazzi A., Bardgett R.D., Barrios E., Behan-Pelletier V., Briones M.J.I., Chotte J.-L., De Deyn G.B., Eggleton P., Fierer N., Fraser T., Hedlund K., Jeffery S., Johnson N.C., Jones A., et al. (2016) Global Soil Biodiversity Atlas http://esdac.jrc.ec.europa.eu/content/global-soil-biodiversity-atlas

Keynote
George Kowalchuk

DEFINING RULES OF MICROBIAL DIVERSITY AND COMMUNITY ASSEMBLY IN SOIL

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Soil-borne microbial diversity is vast and responsible for numerous critical soil functions. While advances in molecular and genomics tools are providing a new-found appreciation of the diversity of soil microbes, we still generally lack the ability to steer microbial communities in soil in such a way as to optimise their functioning. To date, most attempts to exploit soil microbes, for instance for the biological control of plant diseases, have had limited or unreliable success. I argue that we need to examine and understand the ecology of microbial interactions, as relevant at the scale that microbes perceive and interact with their environment, in order to fully make use of the powers locked within soil microbial communities. Via a series of examples, I seek to illustrate how ecological interactions, such as relative niche overlap, complementarity, life-history traits and priority effects can dictate the functionality of microbial consortia. Trait-based ecological approaches have been highly informative and useful in other branches of ecology, and I further propose that such approaches can lead to informed use of microbial activities in soil. It is becoming increasingly evident that we need to understand microbial diversity and functioning in soil as we seek sustainable sue of soil for production and natural ecosystem services. Defining the rules by which microbial communities are assembled will help us to design more informed strategies for utilizing soil-borne microbial diversity to the benefit of sustainable land use.

Parallel Session

Biodiversity 1

SOIL FOOD WEB ASSEMBLY AND VEGETATION DEVELOPMENT IN A GLACIAL CHRONOSEQUENCE IN ICELAND

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Soil is the most important natural resource for life on Earth after water, and provides important ecosystem services, such as food and fibre production, carbon sequestration and nutrient cycling. It is therefore essential that we are aware of the importance of protecting soil, and at the same time understand processes that build up and regenerate soil. This requires study of soil ecosystem development.

Glaciers are retreating due to the temperature rise of the last decades and provide natural chronosequences in soil formation and weathering. By this, retracting glaciers create ideal model systems for studying soil formation and the concomitant colonization and succession of above- and belowground organisms.

We analysed soil food web development and vegetation succession during soil formation in five soil age groups ranging from 1 year old to 120 year old soils, along the retreating glacier Skaftafelljokull in SE Iceland. We hypothesised that along nutrient content, vegetation cover and plant species richness, the soil food webs show increases in biomass and complexity. We investigated soil food webs in terms of the presence and abundance of microbes (bacteria, fungi) and soil fauna (protozoa and nematodes), representing dominant taxonomic groups and trophic levels in soil communities. Furthermore, the soils were characterized in terms of soil pH, C and N pools, C and N mineralisation rates, and plant species cover and composition.

We indeed saw soil ecosystem development according our expectations, i.e. an increase in soil carbon and nitrogen, vegetation cover and plant species richness, a developing soil food web structure and an increase soil organism biomass (total and per trophic group). The development of the soil food web will be linked with aboveground vegetation development and implications for soil ecosystem functioning in terms of nutrient cycling and productivity will be discussed.

CHANGES IN SOIL BIOTA NETWORKS DURING SECONDARY SUCCESSION: IS IT BIODIVERSITY OR NETWORK STRUCTURE THAT DETERMINES SOIL FUNCTION?

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Soil organisms have an important role in aboveground community dynamics and ecosystem functioning. However, most studies have considered soil biota as a black box or focussed on specific groups, whereas little is known about entire soil networks. Here we present results that during the course of nature restoration on abandoned arable land a compositional shift in soil biota, preceded by tightening of the belowground networks, corresponds with enhanced efficiency of carbon uptake. We discovered that already at an early stage in succession half the amount of carbon that flows from plants into soil is taken up by the soil fungi. After 30 years, that share has risen to three quarters of the plant-derived carbon stored in the soil. By labelling the carbon atoms, we were able to follow the carbon flow into the soil food web. In this way, we could link the organisms to their corresponding functions in the community. In an additional experiment we manipulated soil biodiversity to be able to couple biodiversity loss to loss of soil functions. We hypothesized that biodiversity loss would lead to less N uptake by plants and slower C transfer to microbes. We used dual labelled 15N ammonium nitrate (15NH415NO3) and 13C in the form of 13CO2 fed to the plants to assess the faith of the C and N followed by sequential sampling of plant tissue and soil bacterial and fungal PLFA and NLFA biomarkers. This was further related to the amount of recently photosynthesized carbon plants allocated to different microbial groups in soils. Microbial end-communities were pyrosequenced to evaluate the end diversity. In this study we showed the effects of the loss of soil biodiversity to C and N cycling in plants and microbes and compare that to the overall non-manipulated changes over succession in the entire soil community network.

HOW ABIOTIC ENVIRONMENT AFFECTS PLANT SPECIES RICHNESS WITHIN DISTINCT MYCORRHIZAL TYPES?

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Mycorrhiza, a symbiotic relationship between plant and fungi is among the most important belowground biodiversity mechanisms controlling plant-soil interactions. The most wide-spread types of this symbiosis are Arbuscular mycorrhiza (AM), Ericoid Mycorrhiza (ErM) and ectomycorrhiza (EcM). It is increasingly recognized that biodiversity supports resilience of ecosystems and their resistance to environmental perturbations. Given that distinct types of mycorrhizas are known to mediate ecosystem functioning in through mechanisms it is important to understand global patterns of plant species richness within mycorrhizal types, and environmental drivers thereof. We examined which abiotic environmental factors (i.e. soil and climate parameters) determine geographical distribution patterns of plant species richness within most common mycorrhizal types. Based on an exhaustive literature search we have compiled a database of mycorrhiza-plant associations for South and North America continents, holding information on per-plant-species type of mycorrhiza for 5.000 plant species. Using literature sources, and the data available via Global Biodiversity Information Facility, GBIF (http://www.gbif.org/), we combined the geographical information of registered occurrence of individual plant species and the data of the plant species mycorrhizal type (AM, EcM, ErM or non-mycorrhizal). Using these data we have analyzed relationships between relative fractions of AM, EcM and ErM plant species within local species pools and environmental predictors, and created maps showing proportion of plant species associated with each the three mycorrhiza types on American continents. We show that climate, mostly temperature regime, is the most imprtnat factor mediating relative fractions of AM, EcM and ErM plant species within regional species pools. Additionally, fractions of ectomycorrhizal plant species number and ericoid mycorrhizal plant species number were highly correlated with the soil pH. We conclude that different environmental factors predict species richness and abundance of AM plants while for EcM and ErM plant species richness and abundance is controlled by a similar set environmental factors.

ABIOTIC AND BIOTIC DRIVERS IN P-NUTRITION IN CALCAREOUS AND ACIDIC DUNE SOILS WITH DIFFERENT SOIL ORGANIC MATTER CONTENT

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In natural ecosystems, P-nutrition is regulated by factors such as pH, soil organic matter (OM) and microbial behaviour. We tested P-availability in calcareous and acidic coastal dune soils with low, intermediate and high OM, with fractionation methods and laboratory incubation experiments. Inorganic and organic P, and P in nanoparticles and fine colloids shifted over the soil gradients. Iron-bound P did not differ between soil types, but the form of iron changed from mineral in calcareous soil to organic in acidic soil, in accord with the increase in humic acids, which points to relatively weak P-sorption to Fe-OM complexes. Microbial behaviour also differed. Soil respiration and net N-mineralization were similar in all soil types, but DOC-production and net P-mineralization were clearly higher in calcareous than acidic soil. In calcareous soil, low microbial C:P and N:P ratios in fresh soil, and lack of changes in microbial P in incubated soil despite a clear increase in microbial C, suggest that P was not a microbial limiting factor. This may point to the presence of VA-mycorrhiza, which are important for many calcareous dune plants. In contrast, in acidic fresh soil, high microbial C:P and N:P ratios clearly pointed to microbial P-limitation. At first sight, this could be due to high P-sorption in the iron-rich acidic soil, which could also explain low net P-mineralization. However, strong P-sorption is unlikely, as microbial P showed a more than fourfold increase during incubation, and C:P and N:P ratios strongly decreased, which point to increased P-uptake when plant roots are absent. Acidic dunes are dominated by the nonmycorrhizal *Carex arenaria*, and microbial P-uptake in fresh soil is possibly inhibited by high carboxylate exudation by plant roots rather than chemical sorption. This study suggests that calcareous and acidic dune soils differ in P-fractions, but also in biological uptake strategies.

LEGACY EFFECTS OF DIVERSITY IN SPACE AND TIME DRIVEN BY WINTER COVER CROP BIOMASS AND NITROGEN CONCENTRATION

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Plant diversity can increase N-cycling and decrease soil-borne pests, which are feedback mechanisms influencing subsequent plant growth. The relative strength of these mechanisms is unclear, as is the influence of preceding plant quantity and quality. Here, we studied how plant diversity in space and time influences subsequent crop growth.

During two years, we rotated two main crops with four winter cover crop (WCC) species in monocultures and mixtures. We hypothesised that WCC mixtures promote WCC biomass and nitrogen concentration, soil mineral nitrogen, soil organic matter, and reduce plant-feeding nematode abundance. Additionally, we predicted that preceding crops modified WCC legacies. By structural equation modelling (SEM), we tested the relative importance of WCC shoot biomass and nitrogen concentration on succeeding crop productivity directly, and indirectly via N-cycling and root-feeding nematode abundance.

WCC shoot biomass, soil properties and succeeding *Avena sativa* productivity were affected by first-season cropping, whereas subsequent *Cichorium endivia* only responded to WCC treatments. WCC mixture productivity and nitrogen concentration showed over- and underyielding, depending on mixture composition. Soil nitrogen and nematode abundance did not display WCC mixture effects. Soil organic matter was lower than expected after *Raphanus sativus* + *Vicia sativa* mixture. Subsequent *Avena* productivity depended upon mixture composition, whereas final *Cichorium* productivity was unresponsive to WCC mixtures. SEM indicated that WCC legacy effects on subsequent-crop productivity were driven by WCC biomass and nitrogen concentration, although not by the quantified soil properties.

Through understanding plant-soil feedback, legacy effects of plant species and species mixtures can be employed for sustainable agro-ecosystem management. Biomass and nitrogen concentration of plants returned to soil stimulate subsequent plant productivity and these can both be optimised with adequate WCC mixtures. The specificity of spatial and temporal diversity effects warrants consideration of plant species choice in mixtures and rotations for optimal employment of beneficial legacy effects.

DETERMINATION OF SOIL QUALITY INDICATORS BY LABILE CARBON AND NEMATODE COMMUNITIES IN 10 EUROPEAN LONG-TERM AGRICULTURAL FIELD TRIALS

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Soil quality is defined as the capacity of a soil to function within ecosystem and land-use boundaries. Agricultural soils can, in principle, sustain a wide range of functions.

Natural and anthropogenic soil threats, such as soil erosion, have the potential to permanently damage soil quality. The specific objective of this study is to assess the suitability of biological/biochemical parameters as soil quality indicators, due to the unique role of soil biota in soil functions and to their high sensitivity to disturbances. We measured three labile organic carbon pools: dissolved organic carbon (DOC), permanganate oxidizable carbon (POXC), and hot water extractable carbon (HWEC). Additionally, total nematode abundance has been assessed with qPCR. The parameters have been assessed in ten European long-term field experiments with different management regimes and pedo-climatic characteristics. The contrasts in agricultural management are represented by conventional/reduced tillage, and organic/mineral fertilization. These parameters have been related to soil functions measured with a minimum data set of chemical, physical and biological indicators for soil quality. We found a significant correlation between labile carbon pools, especially between POXC/DOC ($\rho=0.6$, $p<0.0001$) and POXC/HWEC ($\rho=0.43$, $p<0.0001$). Only POXC and HWEC were increased by reduced tillage ($F=18.21$, $p<0.0001$ and $F=11.32$, $p=0.001$ respectively), while organic fertilization increased significantly all the pools across the 10 experiments. POXC resulted to be one of the most sensitive and, at the same time, cheapest labile carbon measure. Moreover, POXC resulted to be strongly correlated with total organic carbon ($\rho=0.8$, $p<0.001$), chemical (e.g. CEC $\rho=0.45$, $p<0.0001$), biological (e.g. microbial biomass $\rho=0.6$, $p<0.0001$) and physical (e.g. water stable aggregate $\rho=0.6$, $p<0.01$) parameters. Management effects on nematode abundance were site-dependent and variable in tillage plots, while the application of organic manure generally resulted in higher abundance. Nematode taxonomic diversity will be analysed in spring 2017; results will be presented during the congress.

Parallel Session

Biodiversity 2

DEVELOPING A FRAMEWORK FOR INTERSPECIES EXTRAPOLATION IN SOIL ECOTOXICOLOGY

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To understand and ultimately predict the sensitivity of soil invertebrate to chemical pollutants (e.g. pesticides), a robust and scientifically based ecotoxicological framework for interspecies ecotoxicological extrapolation is needed. In this paper, we will present the basis for such an integrating model. Our approach links toxicokinetic measurements of chemical uptake with genome based and in-*silico* predictions of the toxicodynamic interactions between a toxicant and its known receptor proteins to understand the nature and strength of the molecular initiating events that underpin toxicity. The results of these interactions are then placed within an Adverse Outcome Pathway (AOP) model to link the causes of toxicity to apical phenotypes. To populate and parameterise the overall framework, we use data from previously known and experimental derived differences in the sensitivity of arthropods and a range of different earthworm species to polycyclic aromatic hydrocarbons and organophosphate insecticides as the starting point. Within these case studies, the role of toxicokinetics in determining sensitivity is interpreted by assessing the Accumulation, Distribution, Metabolism, and Excretion (ADME) of the chemical into the body and to the neurological tissues that are the common target for the compounds tested. The contribution of toxicodynamic traits to variations in sensitivity is assessed through genome analysis and tissues specific gene expression measurements to identify 1) the number, nature and activity of key receptor genes present, and 2) molecular docking affinities as affected by the amino acid substitutions present in different species receptor homologues. Finally, to assess how these interactions affect the key biochemical and physiological parameters lead to overt toxicity, we use gene expression, biochemistry and life-cycle measurements. By combining these different approaches and identifying key traits, we seek to improve interspecies extrapolation, better predict species vulnerability, and thereby improved the basis for soil species protection during chemical registration.

CAN EARTHWORM GUT BACTERIA REMEDIATE MICROPLASTIC CONTAMINATED SOILS?

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Plastic pollution is an international problem, aquatic organisms have shown to be affected by the plastic debris. In terrestrial environment, the earthworm Lumbricus terrestris (Oligochaeta, lumbricidae) has shown to change its feeding habits and underlie microplastic decay during the gut passage (Huerta Lwanga et al. 2016). We hypothesized that this decay is caused by microbial activity.

Therefore, the aim of the present study was to isolate and identify bacteria from the gut of Lumbricus terrestris and to study their effect on microplastics in soil. The gut bacteria identified based on 16S rDNA amplification were Microbacterium awajiense, Sporosarcina globispora, Bacillus simplex, Rhodococcus jostii, Mycobacterium vanbaalenii, and Streptomyces fulvissimus.

We conducted a one month experiment with this mix of isolated bacteria (Ba). We mixed gamma sterile soil with 1% w/w microplastics (MP, 150 µm light density Polyethylene) and established 5 treatments (Ba+MP, Ba+MP+Nutrients, Ba, MP, Ba+Nutrients) with 4 replicas. Every week microplastics in soil were quantified, and bacteria were counted, additionally at 3 time points the volatile blend were measured.

In the treatments with Ba+MP, Ba+MP+Nutrients microplastic content in soil was reduced by 60% and the particle size was significantly reduced showing a high number of smaller particles, even nanoparticles at the end of the experiment (from an average of 53.1-41.3 to 35.4-23.6 µm). In the control treatment without bacteria, no microplastic reduction took place. Further studies are required in order to quantify the amount of nanoplastics produced and their fate in the environment.

Huerta E., Gertsen H., Gooren H., Peters P., Salánki T., van der Ploeg M., Besseling E., Koelmans A.A., Geissen V. 2016. Microplastics in the Terrestrial Ecosystem: Implications for Lumbricus terrestris (Oligochaeta, Lumbricidae). Environmental Science and Technology. DOI: 10.1021/acs.est.5b05478, 50, 2685-2691.

THE EVALUATION OF OIL CONTAMINATED SOILS IN TIME (THE NORTHERN PART OF SAKHALIN ISLAND)

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This paper presents the assessment results of the Sakhalin Island soils (northern part) under oil impact in time. Sakhalin Island is one of the oldest oil producing regions in Russia; the oil extraction, transportation, storage lead to soil contamination and require studying of the soil resistance to oil, the oil transformation processes in time and the soil evaluation. Characteristics of polluted podzol and peat soils in conditions of short (1 year) and long (25 years) term crude oil contamination and unpolluted soils analogues were studied. Chemical parameters were measured to characterize the peculiarities and factors of petroleum hydrocarbons (PH) migration vertically and laterally in soil profiles and catena, to reveal the transformation degree of PH in soils in time. Biological indicators (catalase activity, terrestrial plant test) were used to assess the soil functioning in PH short and long term presents in soils. The total PH content in oil contaminated soils varies from 2,0 to 54,0 g/kg in peat horizons and from 1,5 to 26,0 g/kg in mineral horizons. The study revealed that the oil income into soils led to PH downward migration up to a depth of 70 cm with accumulation in peat horizons, as well as lateral and surface migrations. The pH reaction of unpolluted soils varied from 4,2 up to 5,0, while in oil-contaminated soils pH values changed by 1.5-2 units to alkalization. Analysis of oil polluted soils in time provided information about changes in PH fractional composition: the high-boiling fraction domination, changes of the oil biodegradation degree ((pristane+phytane)/(nC_{17}+nC_{18})) up to 40 times and geochemical parameter CPI shift up to 6 times in oil long term polluted soils in comparison with 1-year oil polluted soils. The oil resinous-asphaltene components, persisting in soils up to 25years, have less toxicity, determined by biological methods.

SOIL RESTORATION IN VARIOUS RECLAMATION TECHNIQUES IN COMPARISON WITH UNASSISTED RECOVERY

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Surface mining causes disturbance of large areas. Material excavated from above the mined deposit is transferred elsewhere and new ecosystems are reconstructed here either with help of technical reclamation or by natural processes. When we evaluate efficiency of individual restoration measures we typically compare individual restoration treatments or compare them with initial state or similar ecosystem in surrounding landscape. We argue that sensible way to show added value of restoration measure is to compare them with unassisted ecosystem development. Case study of ecosystem development in Sokolov post mining district (Czech Republic) show that spontaneous succession of ecosystem can be, in many parameters, comparable with various reclamation approaches. In both cases for example the rat of soil C sequestration is typically faster than in arable land. In suitable substrates the succession is driven mainly by site topography. In sites which were leveled grassy vegetation develops. In sites where original wave like topography was preserved the ecosystem develops towards forest. In forest sites the development on most of the investigated ecosystem parameters (cower, biomass soil developments, water holding capacity, carbon storage) in succession sites is little bit slower compare to reclaimed plantation during first 15-20 years. However in older sites differences disappear and succession sites show similarity with restored sites. Despite similarity in these ecosystem functions possibilities of spontaneous sites for commercial use has to be explored.

CAN SOIL ARTHROPOD SPECIES DIVERSITY, IN POST-MINING UNRECLAIMED SITES, BENEFIT FROM SOME LEVEL OF INTERVENTION? A CASE STUDY IN SOKOLOV POST-MINING SITES, CZECHIA

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Mining activities, specifically open cast mining, generate massive ecological damage. However, recently it has been demonstrated that unreclaimed post-mining sites can provide valuable habitats for many rare and endangered species and hence are more favored rather than the reclamation approach. Yet, the species diversity and its related variability inside of the unreclaimed sites is under-represented, understanding of which could be valuable for the species preservation concerns. Hence we investigated the potential differences between wavy and leveled sites, as representatives of surface heterogeneity and homogeneity inside of a spontaneous succession site, regarding their species diversity and conservation values. We focused on several focal groups of arthropods namely moths, spiders, ground beetles, ants, orthopteroids, centipedes, and millipedes. Pitfall and light traps have been installed, and the captured material was collected seven times during a period of three months in 2014. Our results indicated that the species richness values of moths and centipedes were significantly, and for ants and orthopteroids with a clear trend, higher in wavy surfaces. Meanwhile, for diplopods, it was greater in the leveled surfaces. Despite no statistical difference in the species richness values of spiders and ground beetles, red listed members of the latter were correlated with the leveled surfaces whereas the conservation value of the former was significantly higher in the wavy surfaces. Adopting the wavy surfaces rather than the leveled surfaces, or vice versa, does exclude some of the species of biological concern that could succeed otherwise. A landscape matrix, hence, is recommended instead of an evenly applied surface design which requires some level of intervention, i.e. an assisted spontaneous succession. Additionally, in longer time scales, preventing the created open lands from reaching the subsequent stages, which will cease to support the conservation concerns on which the design is based, is rather necessary.

STRUCTURAL CHANGES OF PHYTOCENOSE AND MICROBIAL COMMUNITY AFTER LONG–TERM APPLICATION OF GLYPHOSATE

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The ecology of the agricultural biocenosis that annually applied herbicides glyphosate (HG) in the southern taiga zone (soddy-podzolic soil, humus 2.8-3.0%; pH 5.9-6.1) has been studied. Monitoring of phytocenosis and soil properties was carried out by classical methods of geobotany and soil science. The method of microbial analysis based on gas chromatography-mass spectrometry (GC-MS) of fatty acids, hydroxy acids and aldehydes of fatty acids was used. The analysis of data during 17 years has been made by methods of mathematical statistics (Stat Soft, STATISTICA, version 10). Use of HG has reduced amount (by 36-100%) and biomass (by 61-96%) of all plants. The species with the r-strategy of growth were dominated in plant's community in the 17th year of an experiment. The "species core" of the phytocenosis consisted of spring weeds: *Spergula arvensis* L., *Chenopodium* sp., *Galeopsis tetrahit* L., *Polygonum* sp. (45%) and wintering weeds: *Viola arvensis* Murr., *Matricaria inodora* L., *Lamium purpureum* L., *Capsella bursa-pastoris* (L.) (35%).The total number of microorganisms decreased to 1.4×10^7 cells / g, compared to the beginning of the experiment - 5.5×10^7 cells / g. However, the number of spore-forming species of *Bacillus subtilis* and *Clostridium pasteurianum*, ubiquitous *Arthrobacter globiformis*, actinobacteria *Pseudonocardia* sp. remained the same in different years of observations (27-41%).The increase in number of *Rhodococcus* sp., *Butyrivibrio* sp. and *Acetobacter diazotrophicus* has been observed. The number of *Rhodococcus equi*, *Methylococcus* sp., *Streptomyces* sp. became below sensitivity of a method GC-MS ($< 10^4$ cells / g). Therefore, systematic use of HG caused structural changes in the phytocenosis and microbial community. The species composition in the artificial biocenosis became poorer, but the number of some species has increased. The amount of micromycetes has decreased (by 41-53%), and bacteria has increased (by 20-75%) in microbial community of the soil.

Theme 6

Food security

Keynote

Shamie Zingore

LOW CROP YIELDS AND YIELD QUALITY IN SUB-SAHARAN AFRICA: THE SOIL QUALITY AND NUTRIENT MANAGEMENT NEXUS

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Many countries in sub-Saharan Africa (SSA) face the challenge of worsening food insecurity underpinned by low crop yields and a rapidly growing population, which is projected to double to 2.1 billion in 2050. Sustainable intensification of smallholder agriculture in SSA is imperative to reduce the large food supply deficit and reverse the current trends of soil nutrient depletion and land degradation (Sanchez, 2010; Ray et al., 2013). Attention to crop and soil management practices that enhance the nutritional quality of food produced will also be necessary to tackle the problems of malnutrition that affect rural households which depend primarily on on-farm production for dietary needs. This paper examines the two-fold influence of inherent and management factors on soil quality, and how this affects crop productivity and yield quality in smallholder farming systems in SSA. The implications of soil fertility heterogeneity on nutrient response patterns and appropriateness of nutrient management practices for crop production intensification at various time scales are also explored.

The majority of soils in SSA are inherently infertile (with a bedrock consisting of mostly granites and gneiss) except for small areas of more fertile soil associated with recent volcanic activity found in the eastern African highland areas. As a result, large areas have soils that are characterized by clay fractions dominated by kaolinite and sesquioxides, low nutrient contents, high acidity, and high fixation capacities for P (Deckers et al., 2000). Inappropriate management practices such as continuous cultivation with minimal nutrient applications and soil erosion further exacerbate infertility of the inherently poor soils resulting in severe nutrient depletion and decline in organic matter. As a consequence, SSA remains the only region of the world with large negative and declining nutrient balances (Fixen et al., 2015) and where chemical and physical degradation (including soil acidity and Al toxicity) affect more than 60% of the agricultural land (Muchena et al., 2005; Vlek et al., 2008).

Reversing the degradation and increasing crop productivity for the soils in SSA requires a complex set of soil fertility management options (Zingore et al., 2011). Due their low buffering capacity, sandy soils are particularly susceptible to degradation and more difficult to manage to restore productivity. In north-east Zimbabwe, restoration of degraded sandy soils required huge amounts of manure in combination with fertilizer for multiple seasons before meaningful productivity levels could be achieved. Yield gaps between fertile and degraded sandy soils were still evident even after 10 years of manure and fertilizer application, suggesting the existence of complex chemical, physical and biological constraints that are not easily addressed by organic matter and fertilizer management. On the contrary, clay soils showed high resilience to N and P responses, with constrains to production mainly associated with nutrient imbalances.

Depleted clay soils were more readily restored to optimal productivity with balanced fertilization and manure application.

The complex variability of soils at various spatial scales brought about by different inherent and management practices have a major influence on the suitability of nutrient management practices. Data from multi-location nutrient omission trials to diagnose nutrient deficiencies from a wide range of studies consistently show N and P to be the most limiting nutrients, but also reveal high variability in response to application of macronutrients. It is increasingly evident that, while N and P are the most limiting nutrients, there is high occurrence of soils that respond poorly to the application of N and P fertilizers (Vanlauwe et al. 2011). Understanding of the nutrient response patterns and associated factors is key to improve fertilizer recommendations to optimize productivity. A recent study by Kihara et al. (2016) covering more than 400 fertilizer response trial sites established that nutrient response patterns can be divided into two broad ‘responsive’ and ‘non-responsive’ clusters (Figure 1). Two ‘non-responsive’ soil clusters were further disaggregated into the the fertile and infertile sub-clusters. In the non-responsive infertile sub-cluster, very low yields are achieved and crops respond poorly to fertilizers even when other amendments were applied (organic matter and application, lime), while high availability of nutrients preclude significant responses to fertilizer fields in the non-responsive fertile sub-cluster. The responsive soils showed three characteristic macronutrient response patterns: (i) fields that respond strongly to N alone (cluster 4); (ii) fields that respond strongly to combined application of N and P (cluster 2); and (iii) fields that show limited response to N, P and K. Across all the responsive clusters, yields were increased by 10-30% by the addition of secondary and micronutrients.

The need for secondary and micronutrients is gaining increasing recognition, not only due to their importance in increasing crop productivity (Kihara et al. 2017), but also their association with micronutrient availability in the food produced and consumed by smallholder farmers in SSA. The influence of soil micronutrient deficiencies on low micronutrient contents of crops and human micronutrient deficiencies in SSA is particularly evident for Zn and Se. For example, low Zn dietary intake in Uganda was found to be associated with low soil Zn availability (Tidemann-Andersen et al. 2011). In Malawi, Chilimba et al. (2012) measured widespread soil Se deficiencies that translated into low Se dietary intake in maize-based farming systems, which was less than 50% of recommended values. Application of organic nutrient resources and fertilizers that contain micronutrients to deficient soils is an effective bio-fortification strategy to enhance the grain content of Zn and Se (Cakmak 2002; Chilimba et al. 2012). While application of Se has no influence on yield, as is not essential for plants, its application through fertilizer provides an option for improving Se nutrition for populations in Se deficient soils.

To achieve sustainable crop production intensification in SSA, soil and nutrient management recommendations must therefore focus not only on increasing crop productivity, but also increasing the nutritional value of the food produced. Improving management of nutrients and crops will require tools that enable reliable and cost effective diagnosis of soil chemical and physical constraints and provide recommendations that are appropriate for the complex crop response patterns. Strengthening research linkage to public and private sector agricultural development programs offer the best prospects to achieve impact by guiding large-scale and long-term investments in technologies that address the multiple constraints and functions of smallholder crop production systems, including income and food and nutritional security.

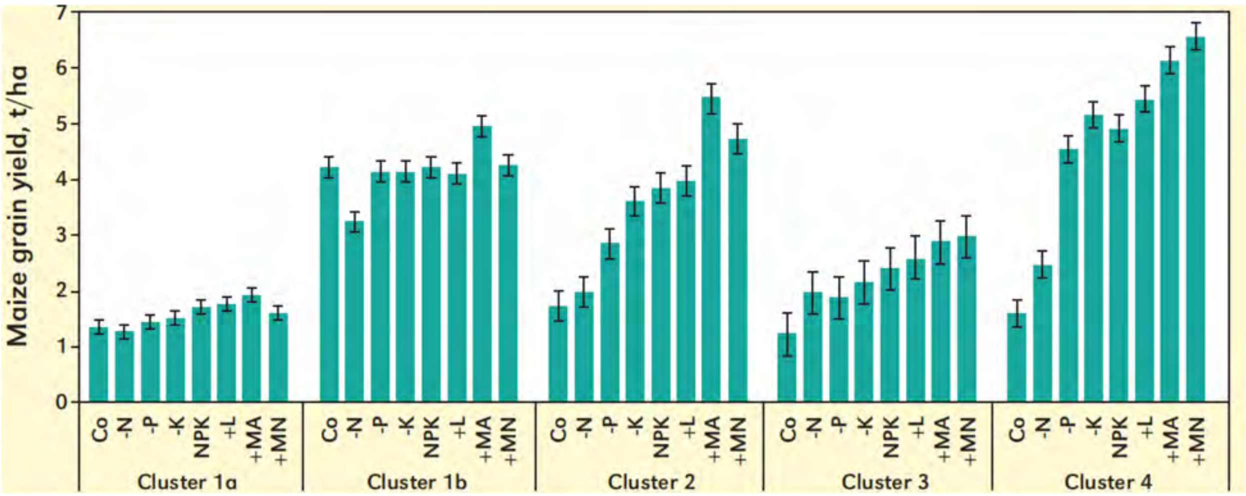

Figure 1. Maize grain yield observed from sub-Saharan Africa fields classified under different clustersfollowing K-Means clustering. Error bars are standard errors of the estimates. Co = Control; -N, -P, -K = omission plots; NPK = macronutrients; +L = NPK+lime; +Ma = NPK+manure; +Mn =NPK+Ca, Mg, S, Zn, B.

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Keynote
Pablo Tittonell

SOIL SCIENCE AND FOOD SECURITY: EMBRACING SUSTAINABILITY, COMPLEXITY AND UNCERTAINTY

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The intensification of agricultural production in the most vulnerable regions of the world is imperative to meet food security and the various United Nations Sustainable Development Goals (SDG) (Keesstra et al., 2016). Yet the means to achieve agricultural intensification must be tailored to the social-ecological contexts where productivity increases are needed. It is of little help to keep raising yields in developed regions and countries, heavily subsidised and with high environmental impact, as this production rarely reaches the poor in the poorest regions of the world (Tittonell et al., 2016). Only a fraction of the energy contained in the food produced in developed regions is delivered to the food system (cf. Cassidy et al., 2013), suggesting that it is not a good idea to leave food security in private hands, in the hands of the international market. Food must be produced where food is most needed. And it is not enough to think only about production and productivity, because we all know that food security is made up of food availability, access, stability and utilization (WHO, 2017). The capacity of human bodies to utilize food depends, among other things, on the possibility to cook food, which is often limited by the availability of fuelwood in poor regions, and on ingesting the right balance of nutrients with the diet (FAO, 2017). This means that food security, energy security and human nutrition are tightly interlocked.

More than half of the ca. 800 million people that are in a situation of hunger are rural dwellers, many of them farmers, that possess small portions of land where food can be produced (SOFI, 2015, http://www.fao.org/hunger/en/). They tend to be located in areas that are poorly served by infrastructure, information and markets, variously affected by the climate and its variability, and often farming on degraded or inherently poor soils. What model of agriculture intensification can work in such contexts? For the past four decades, international agencies, governments, scientific institutions and non-governmental organisations have been promoting agricultural intensification technologies that fit the production systems and models developed during the green revolution. The Alliance for the Green Revolution in Africa (AGRA) or the Abuja Fertiliser Summit conveyed by the African Development Bank are conspicuous examples of that for the African continent. Yet, in spite of the push for new germplasm, irrigation schemes, sometimes mechanisation, very often fertilisers, veterinary and other synthetic inputs, food production per capita in most of sub-Saharan Africa remains at the same level as in the 1960s (cf. FAO Stat and SOFI, 2015).

This is not necessarily proof that the above mentioned agricultural technologies are of no use. Individually taken, they have been often shown to improve the production – if not always the productivity – of single crops or animals, normally under controlled experimental conditions or in researcher-managed or project-supported demonstrations in farmer fields. But their true impact on food security and nutrition has been seldom documented beyond such isolated examples, beyond the time horizon of externally funded research or development projects. There are many reasons that could be put forward to analyse such failure. From a soil scientist´s perspective, I propose to analyse these reasons by examining them from three perspectives: sustainability, complexity and uncertainty. These are three dimensions inherent to social-ecological systems that need to be considered for better targeting our efforts in research, developing and policy making to address food insecurity. During the conference, I will illustrate this with concrete examples, as the one below.

The Malawi case

The Farm Input Subsidy Program (FISP), often referred to as the ´Fertiliser Program´ launched by the Malawi Government with the aid of international donors in 2005 has been frequently used as an example of how well-directed subsidies can contribute to improving food security (e.g., https://oxfamblogs.org/fp2p/how-fertiliser-subsidies-have-transformed-malawi), and of how fertiliser use is key to achieving food security in Africa (e.g., Denning et al., 2009). Lately, however, many voices were raised to criticise the limited impact of this program, to point out farmers´ negative perceptions on it, and even to document deficiencies in assessing actual productivity impacts (e.g. http://www.times.mw/malaw-has-wasted-k288-9-billion-on-farm-input-subsidy-programme/). According to FAO´s datasets, grain yields in Malawi fluctuated around 1 t/ha from 1961 to 1990, at around 1.2 t/ha from 1990 to 2005 and around 2 t/ha from then on (Figure 1A). Yet, productivity increases that were reported by the government (MoAF), and hence captured in FAO´s database, were not confirmed by other estimates, notably those obtained through remote sensing (Messina et al., 2017 - Figure 1B). Maize grain yields estimated in this way (biomass) using a harvest index (HI) of 0.4 were in the order of pre-FISP yield levels. Yields estimated with an optimistic HI of 0.6 were still below the yields reported by MoAF for 2009-2012.

Table 1: National-level indicators of productivity, response to fertilisers and costs in the first four years of Malawi´s FISP (source: Dorward and Chirwa, 2011)

	2006	2007	2008	2009
Total maize production (MT)	975,262	1,698,956	1,031,938	2,031,816
Total fertiliser use (MT)	98,541	113,547	140,760	181,800
Grain to fertilizer	9.90	14.96	7.33	11.18
Incremental grain to fertiliser	-2.79	3.95	-1.55	4.30
Fertiliser price (us$/MT)	393	490	590	1250
Total program cost (us$ Million)	51.4	90.9	116.8	265.4
Cost as % of GDP	2.1	3.1	3.4	6.6

Incremental grain-to-fertiliser ratio is calculated as the difference in total production between each year and the average for the period 2000-2005 (1,225,000 MT).

In the first four years of FISP implementation (Table1) total maize production doubled at national level according to official figures, and the net maize deficit moved from -78,491 MT to -50,398 MT (Dorward and Chirwa, 2011). Total fertiliser use doubled too, and the increase in the international price of fertiliser resulted in a five-fold increase in the total cost of the subsidy program by 2009. The incremental grain to fertiliser ratios were much below the expected for the region (+/- 25 kg/kg, cf. Whitbread, 2013).

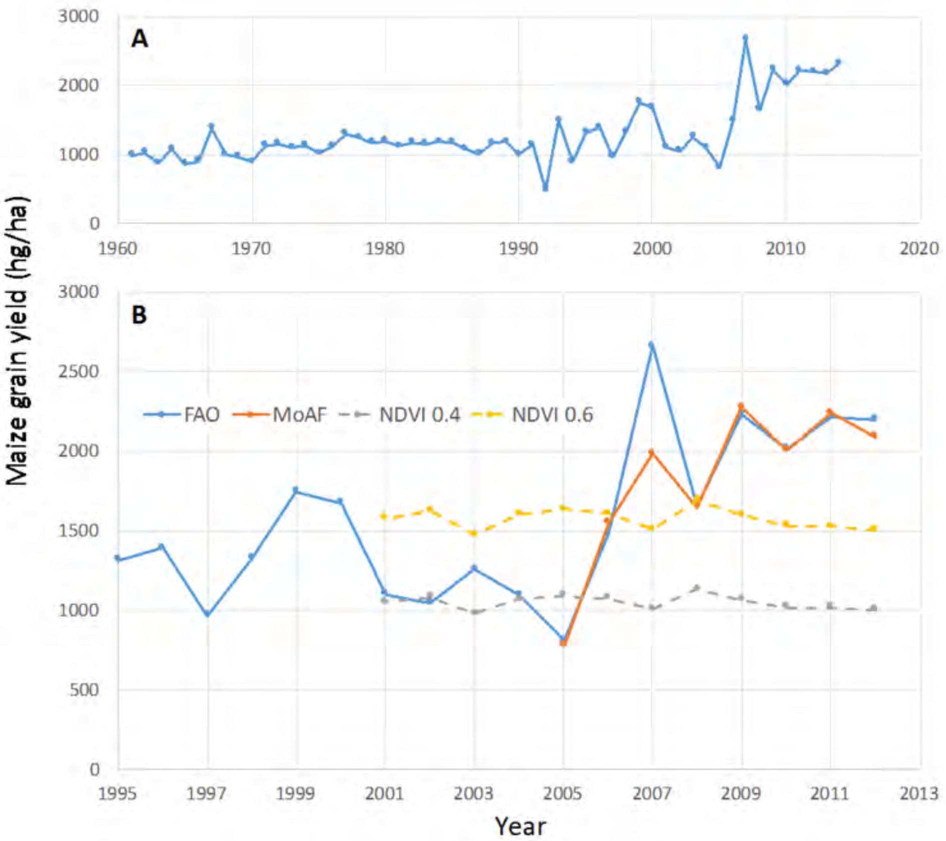

Figure 1: Malawi´s yield statistics. (A) Grain yield 1961-2014 from FAO Stat; (B) Grain yields as reported by the government (MoAF) and in FAO Stat (discrepancies in 2007 originate from an error in actual area estimates by FAO), and as estimated through remote sensing (biomass), considering harvests indexes of 0.4 and 0.6. Source: FAO Stat and Messina et al., 2017.

Why choosing this example? Because it clearly shows that the long term *sustainability* of the subsidy program was not considered. No alternative strategy was deployed as a follow up if or when subsidies would eventually dry out, or as a gradual transition to more sustainable soil management strategies once the most urgent needs of increasing production were fulfilled. The social-ecological *complexity* inherent to smallholder production systems, to local institutional arrangements and factual governance mechanisms on the ground were disregarded, resulting in unforeseen inefficiencies, corruption and frustration, as the poorest households were not the main beneficiaries of this program (Holden and Lunduka, 2010). The *uncertainties*, associated in this case not only with the climate but also with market volatility were not part of the equation, resulting in a subsidy budget following the spike in fertiliser prices that amounted to 6.6% of national GDP (Table 1), creating substantial deficit in the public accounts. In the face of examples such as this one, let us reflect upon how to embed the dimensions of sustainability, complexity and uncertainty within conceptual frameworks that can help to better design and target our efforts to improve soils and food security.

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Parallel Session

Food Security 1

FARMERS' MENTAL MODEL FOR THEIR PERCEPTION OF SOIL PROCESS AND PROPERTY, CASE STUDY IN KITUI, KENYA

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The relationship of soil process and property is one of essential knowledge in soil science because it supports various soil functions. The knowledge about soil is derived not only from soil scientists, farmers also create local knowledge from their own experience. It was described as local or farmers' knowledge of soil in Ethnopedological studies that farmers categorized soils by their own terminology and their fertility evaluation was related to soil scientific values. However, there is little information about how much farmers understand the relationship of soil processes and properties. In addition to that, the focus of Ethnopedological studies was mainly on community area base and the difference in knowledge among farmers in the same community was often ignored. Therefore, the aim of this study is to demonstrate farmers' knowledge about the relationship of soil process and property including the difference of knowledge among farmers in the same community. One kind of mental model, sematic web, is used for showing the results. Mental models have not yet common tools for soil scientific study but they have the benefit of visualization of consistencies and conflicts between soil science and farmers' soil knowledge. Two villages in Kitui, Kenya were selected as the case study sites. In each village, 30 farmers were interviewed regarding their knowledge about soil processes and properties, and the total number of samples was 60. The data from these interviews is analysed using KH coder then sematic web is created. The sematic web of farmers' knowledge about soil process and property is compared with that of soil science.

ORGANIC FERTILIZER AT A CROSS ROAD BETWEEN SOIL HEALTH AND FOOD SECURITY: CASE STUDY FROM WESTERN AMHARA REGION, ETHIOPIA

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In 2016 and 2017 field trials were conducted to evaluate the role of compost to improve soil health and to ensure food security in the highlands of Western Amhara Region, Ethiopia. In addition an inventory of the availability of additional resources in the region was made at the household and regional level. A participatory rural appraisal (PRA) technique was employed to generate data on availability of organic resources at household level from different sources. To evaluate compost quality, compost samples were collected from 18 farmers' that use either the pit or hip composting technology. Soil samples were also collected from four farmers' fields before compost application and after crop harvest. Field experiments were conducted on the farmers' fields where a combination of three compost rates (0 ton/ha, 5 ton/ha, 10 ton/ha) and three mineral fertilizer application rates (no mineral fertiliser, 50% and 100% of the national recommended level) were tested. RCBD design was used for this experiment and the treatments were replicated three times.

The inventory study indicated that in the study area sufficient amounts of organic resources are available from the fattening farms, municipality and households which are crucial for compost preparation. About 150 tons of cattle manure and more than 40 tons of organic resources produced from cattle forage are generated annually. Municipal solid waste management experts said that approximately about 250 m^3 of organic material is being collected per week in the study area. The result indicated that the solid wastes are composed of both biodegradable and non degradable components. Thus, it requires selection and separation of decomposable materials before using them as source material for composting. Currently the most commonly used organic resources for preparation of compost include animal manure, residues of different crops (straw of wheat, faba been, maize), green leaves and ash materials which are mainly available at household level. The survey result indicated that about 65% of the respondents have a positive perception about compost application and they prepared compost continuously. The farmers stated that if the compost is properly prepared and applied at sufficiently high rates, it is effective to maintain the long term soil quality and a sustainable crop production. Although there is a huge potential supply of organic resources available in the study area, local people do not use these organic resources for composting. The major factors influencing preparation and application of compost includes shortage of raw materials around homesteads, labour scarcity for transportation and preparation of compost from municipality wastes and animal farms, scarcity of farm lands and land tenure insecurity.

The soil analysis results showed that the soils of the experimental sites are deficient in N, P, S, Zn and B but sufficient in K and Mg which is supported by data from ATA and has prompted the government to prepare blends for NPSZnB for the study area.

The analysis of 18 compost samples collected from farmers' backyards indicated that the composts are suitable and well matured for application to the field. However, challenges that may limit the use of compost include the long preparation time of compost; the large amount of compost that is required to obtain the equivalent amount of nitrogen as applied via mineral fertilizers; and competing claims for FYM and crop residues.

Results from the maize and tef field experiments revealed that individual as well as combined application of compost and NPSBZn mineral fertilizers improved crop yield and yield components of maize. Moreover, the highest grain yield was obtained from application of 10 tons ha^{-1} compost and full recommended mineral fertilizer rate (200 kg ha^{-1} NPSBZn + 150 kg ha^{-1} urea) Conversely, application of 10 t ha^{-1} compost and half of the recommended mineral fertilizer rate (100 kg ha^{-1} NPSBZn and 75 kg ha^{-1} urea) was found to be economical feasible. Analysis of soil samples after harvest demonstrated that application of sole compost, sole mineral fertilizer as well as their combinations affected soil chemical properties.

From the results of the study, it can be concluded that soils of the study area require nutrient amendment; but that huge amounts of compost are required to meet the nutrient demands. Compost quality prepared by farmers are of acceptable quality and no significant differences in nutrient release rates between heap and peat method of compost preparation were found. Even though inputs for compost making are sufficiently available in the district, they are relatively scarce at household level due to the competing claims for organic resources and compost making since composting is both a time and energy consuming activity. Integrated nutrient management improved crop performance beyond that of sole organic matter or mineral fertilizer treatments. Despite these points of attention, the potential of compost to be used to improve soil health and secure food production is promising provided that awareness creation among farmers is taken care of.

SUSTAINABILITY OF VEGETABLE GARDENING IN THE URBAN SURROUNDINGS OF KISUMU, KENYA AND OUAGADOUGOU, BURKINA FASO

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As part of an interdisciplinary project on empowering women entrepreneurs in the informal settlements in Kisumu, Kenya and Ouagadougou, Burkina Faso, natural and social scientists have joined hands to study the sustainability of vegetable gardening in (peri)urban areas.

The contribution of urban vegetable gardening to food and nutrition security is widely debated. Furthermore, urban agriculture is hypothesized to predominantly take place on marginalized land plots, whereby the intensity and spatial limitations could be expected to lead to irrecoverable soil depletion.

The focus of this study is on three selected vegetable gardening sites in each city, where vegetable gardening is practiced by women farmers organized in (mixed) groups. Social science research methods and in-depth soil descriptions and analysis were combined to test the hypothesis. Topsoil samples were taken along a spatial grid in several urban gardens in Kisumu and Ouagadougou. Preliminary results of analysis of major cations and anions, available nutrients, CEC, and heavy metals with CNS, AAS, XRF and ICP-OES indicate neutral to slightly acidic soils that are medium to rich in nutrients.

Study of the social-economic history of human settlements will shed light on the processes that led to the selection of the locations and subsequent agricultural management of the examined plots that, in part, led to their unexpectedly high fertility. As such, our study illustrates the relevance of interdisciplinary approaches to gaining a comprehensive perspective on soil fertility and food production in the context of urban gardening. Ultimately, interdisciplinary research leads to fundamentally improved understanding of urban agriculture and its role in food and nutrition security for vulnerable populations in informal settlements.

HOW FARMERS' CHARACTERISTICS INFLUENCE SPONTANEOUS SPREADING OF STONE BUNDS IN THE HIGHLANDS OF ETHIOPIA: A CASE STUDY IN THE GIRAR JARSO WOREDA

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Improved production and productivity in the densely populated Ethiopian highlands is possible when sustainable land management technologies are applied to address soil erosion and soil loss. Although some local farmers spontaneously apply certain technologies on their farmland to address soil erosion and soil loss, there is insufficient information on the intrinsic motivation of these farmers when they spontaneously implement and continue to use stone bunds. The central aim of this study is to identify key-differences in household characteristics and motivation between farmers who spontaneously implement stone bunds and farmers who do not in the central highlands of Ethiopia. Data was generated from 80 farmers: 40 spontaneous farmers and 40 non-spontaneous farmers. Principal component analysis and paired-sample t-test were used to analyze the data. Our results showed that five key factors explain differences between the two groups: 1) readiness to change, 2) available resources, 3) bridging social capital, 4) family type, and 5) dedication. These factors explaining about 76% of the variance in farmer's socio-institutional and economic characteristics in combination indicate farmer's intrinsic motivation to continue to use stone bunds implemented on their farmlands and to integrate them into their farming system. This result implies that spontaneous farmers are farmers who are ready to change their future in terms of improving productivity and food security by using available resources and social capital. Moreover, spontaneous farmers are farmers who struggle to conserve and protect their soil from erosion by mobilizing their own family labor and knowledge. The study suggested that extension program should work towards creating farmers readiness to change the future of their farming activities through improving social relations and organization when aiming at fostering sustainable land management. This is particularly important when developing a scaling-up strategy that help increase agricultural production and achieve food security of small-holder farmers in Ethiopia.

CHARACTERIZATION AND MAPPING OF SOILS IN THE ETHIOPIAN HIGHLANDS AND IMPLICATIONS FOR SOIL FERTILITY MANAGEMENT DECISIONS AT FARM LEVEL

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Ethiopia is a country of huge diversities in terms of geological and lithological formations, topographic features and climatic conditions that in turn gave rise to diverse range of soil types. Previous studies have reported that 19 out of the 28 Major Soil Groups (MSGs) of the FAO-UNSECO Soil Map of the World are found in Ethiopia. In view of this, Ethiopia is referred as the "soil museum" of the world. Yet, our knowledge of Ethiopia's soil resource is limited. The soil resource were mapped at 1:2,000,000 but this map is too coarse and topographically not detailed enough to provide functional information for soil fertility decision at lower spatial scale. As result, the soil fertility management at farm level has been constrained by lack site-specific soil resource information of sufficiently detailed nature. Until recently, fertilizer applications have been based on blanket recommendations of 150 kg Di-ammonium phosphate (DAP: 18-46 percent N-P_2O_5) and 100 kg urea (46-0 percent N-P_2O_5) per ha irrespective of soil types and agro-ecologies. This not only proved inappropriate but also insufficiently fine-tuned in the light of the huge diversities in soil types and their properties in the country. Cognizant of the scale of the problem, the Ethiopia-Netherlands bilateral research project, "Capacity building for scaling up of evidence-based best practices for increased agricultural production in Ethiopia (CASCAPE) conducted soil characterization, classification and mapping in 30 high potential districts of the highlands. Morphological, physical and chemical properties of dominant agricultural soils described and classified according to the WRB 2006 conventions at reference Soil Group and soil unit levels. Spatially explicit soil-landscape maps are generated at 1:250,000 scale using Random Forests modeling approach.

Key words: Diversity, Random forest model, soil characterization and mapping

NITROGEN MINERALIZATION AND BIOLOGICAL PROPERTIES OF SOILS FROM UNDER CANOPIES OF CONTRASTING FAIDHERBIA ALBIDA TREES AGES FOLLOWING LITTER AMENDMENT

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Faidherbia albida (Faidherbia) has shown the potential to restore soil fertility status and increase nutrients on smallholder farmers' fields. Previous studies have mainly focused on 'older' trees (>40 years old) but, there is an increasing share of young Faidherbia trees (1-25-years) on many smallholder farmers' fields in Zambia. We compared the fertility status of soils under to outside the canopies of Faidherbia trees. Further, a controlled incubation study was conducted to examine the effect of Faidherbia litter amendment on nitrogen (N) mineralization and soil biological properties on soils from under canopies of 8, 15, 22 and >35-year old Faidherbia trees in Zambia. Soils from under the canopy had 1.1-1.8 times higher soil organic carbon (SOC) and total N than outside canopy soils. The N mineralization rate was nearly double under >35-year canopy soils compared to outside while no differences were observed for other ages. Soil under canopies of 22 and 35-year old trees had respectively 1.4 and 2.8 times more microbial biomass (MB); and dehydrogenase activity was 2-8 times higher under 8, 22 and >35-year old trees. This can be explained by high SOC concentration in soil from under the canopy. Amended soils from 15, 22 and >35-year old trees had higher N mineralization rate compared to unamended soils. Further, dehydrogenase activity was 1.7-3.8 times higher and MB increased by 30-53% in amended compared to unamended soil under 8, 22 and >35-year old trees. Litter amendment increased the abundance of PLFA biomarkers Gram+, Gram- and fungi compared with unamended soils. Generally, soils from 22 and >35-year old trees tended to have higher N mineralization rate, total PLFAs, MB and enzyme activity. Our results show that Faidherbia trees improve soil fertility status under canopies largely due to seasonal litter fall nonetheless, the effect is much larger under older than younger trees.

Parallel Session

Food security 2

UTILITY OF HANDHELD, LOW COST SPECTROSCOPIC DEVICES FOR SOIL AND PLANT TISSUE ANALYSIS

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Numerous spectroscopic modalities have been explored for rapid, non-destructive analyses of soil fertility and plant tissue health, with the goal of replacing or supplementing traditional chemical analyses. The utilities of techniques like near infrared (NIR), mid infrared (MIR), x-ray fluorescence (XRF), and laser induced breakdown spectroscopy (LIBS) have been well documented in the literature. Historically, these devices have been too expensive and typically not portable enough to be useful for on-site analysis, especially in the context of aiding smallholder farmers in the developing world. Recent hardware developments have created dramatically lower cost and smaller footprint devices that could enable widespread use down to the individual farm level, thus allowing more personalized recommendations to increase yields, while also syncing up with large-scale mapping efforts such as the Africa Soils Information Service (AfSIS). To meet this potential, the performance of these new devices must be substantially equivalent to existing higher cost devices.

In this work, we tested the performance of six such devices: three NIR, one MIR, one LIBS, and one Raman spectroscopy. All devices are handheld, and besides the LIBS, all offer current or projected near-term volume pricing ranging from $200 to $2000. The systems were tested on 120 soil samples previously collected by ICRAF from 14 different African countries, and on 26 plant tissue standards that had been ground into a fine powder. Using both traditional chemical analyses and total elemental concentrations from XRF as reference data, we explored the predictive abilities of each device using several machine learning regression approaches.

The predictive performance of the low cost devices ranged from poor to nearly as good as larger, more expensive devices. Future work will then expand the sample sizes for only the most promising instrument(s) to allow for more robust prediction algorithms.

UPTAKE AND IMPACT OF ON THE SPOT FERTILIZER RECOMMENDATION FOR SMALLHOLDER FARMERS IN KENYA USING SENSOR TECHNOLOGY

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Soil fertility decline is one of the most persistent causes of soil degradation worldwide. Continuous extraction of nutrients from the soil is a precursor of a downward spiral of subsequently loss of soil organic matter, lower yields and ultimately degraded, unproductive soils. Preventing soil fertility loss by adequate soil nutrient replenishment is not a scientific question as good techniques for calculating soil nutrient requirements exist. However, these methods are often not specific to local condition, leading to e.g. recommendations of fertilizers that are not available to the farmers. Consequently, adoption rates of fertilizer recommendations are often very low.

SoilCares has developed a portable, easy to use and fast soil Scanner that is taken into the fields to develop on the spot, customized fertilizer recommendation using local conditions and farmer preferences. The Scanner was introduced to the Kenya market in 2017 and is this paper we share our experiences and results.

The Scanner was used by different distributors including amongst others cooperatives, NGOs, local government, input suppliers and private extension. Qualitative surveys were performed on farmer appreciation and customer satisfaction. Also, yield measurements for analysed and non-analysed plots were performed.

Adoption rates of fertilizer recommendations were very high; over 90% of the farmers reported to have changed their fertilizer practices according to the recommendations. The main reason for this was the on the spot effect; farmers received recommendations for their own fields while being there. The main shift in fertilizer habit was the application of lime to alleviate soil pH. Over 70% of the soils in production in Kenya has a pH below 6. The findings of 2017 indicate that by locally adjusted fertilizer recommendations adoption rates increase, which opens the way to halting and reverting soil fertility decline at scale.

DEVELOPING A DECISION SUPPORT TOOL FOR ON-FARM NUTRIENT MANAGEMENT IN NORTHERN ETHIOPIA

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The highlands of Ethiopia, especially the Northern part, are highly degraded due to deforestation, continuous cultivation and lack of soil and water conservation practices. Soil fertility management practices such as fallowing, crop rotation, intercropping, and use of manure and crop residues are not adequately practiced. Absence of these practices without due attention to the fertility level of the soil has led to depletion of plant nutrients and soil organic matter content. As a consequence crop yields are highly hampered. Urea and Diammonium Phosphate only have been used at a rate of 100 kg/ha each as sources of N and P irrespective of soil types and crops for the past five decades. However, recent studies by the Ethiopian Agricultural Transformation Agency have indicated that N, P, K, S, Fe, Zn, B and Cu are deficient in the agricultural soils. The highly heterogeneous nature of the soils means that fertilizer recommendations has become a major challenge. Therefore, this study has been initiated to evaluate crop responses of tef, wheat and sorghum to fertilization based on soil type and management practices. Thus, testing and evaluating new fertilizer entries (blended fertilizers) and quantifying their responses based on soil test and crop uptake will allow us to develop soil, crop, and site specific recommendations that could be affordable to farmers and will contribute to an increase quantity and quality of agricultural produce. In this study, a prototype decision support tool will be developed that takes into account on differences between soils in the provision of nutrients; the availability of organic nutrients; the capacity to cycle organic nutrients and differences between farms and crops in the demand for nutrients.

ROOTS REDESIGN THE SOILS PHYSICAL ARCHITECTURE AND FUNCTION FOR DROUGHT-TOLERANT PLANTS

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The rhizosphere drives plant productivity and is the "powerhouse" of soil function, regulates both water and nutrient uptake by plants. The interaction between the root zone and soil geometry affects water, nutrient and microbial dynamics within the soil. The root architecture and rhizodeposition (such as carbon rich mucilage and exudates) can dramatically alter water and solute flow towards the root. Using high resolution (16µm) micro-computed x-ray tomography, and root metrics, we compared the geometry of soil around drought tolerant and normal chickpea varieties. We found that the drought tolerant varieties had the remarkable capability in redesigning the soil close to their roots by increasing total porosity and connected porosity. We also found that the drought tolerant variety despite exhibiting no increase in root hair length, increased the rhizosheath on the root surface. We linked this to an observed increase in root mucilage. Our results demonstrate the importance of examining the plants 'hidden half' which function as architects and plumbers, micro-engineering their environment to improve water uptake at the root-soil interface.

SOIL AND WEATHER VARIABLES IN RELATION TO THE ANNUAL MINERAL NITROGEN SUPPLY OF DAIRY GRASSLANDS ON PEAT SOILS IN THE NETHERLANDS

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Determination of N mineralisation of drained grasslands on peat soils is complex. As alternative method, annual mineral N supply (AMNS) is used, defined as the amount of N taken up annually by grass in an unfertilised field. Estimates of AMNS are useful for refining farm fertilisation management, in order to improve N use efficiency on grasslands. However, a reliable model for AMNS estimations of peat soils is not available. Therefore, the objective of the current study was to analyse the relationships between historically measured AMNS and soil and weather parameters of unfertilised and fertilised natural and dairy grasslands on peat soils in the Netherlands. Of 36 different experiments, mowing dates and N yields were collected (range 1.4 – 176 kg N ha-1 cut-1, average 63 kg N ha-1 cut-1), as well as fertilisation rates (range 0 – 460 kg N ha-1 year-1, average 30 kg N cut-1 year-1) and measures of soil organic matter (range 29.2 – 65.5%), pH-KCl (range 4.3 – 5.4) and elutriable particles (range 20.0 – 41.3%). Experiments were performed on 16 different locations within the years 1980 till 2015. Historically recorded meteorological data from the nearest weather station (de Bilt or Eelde, KNMI) were used to calculate cumulative average daily temperatures and daily net precipitation by subtracting evaporation from precipitation rates. Data was analysed using a mixed non-linear regression model. The model explained 41% of the total observed variation. Soil organic matter and cumulative average daily temperature showed a positive linear relationship with AMNS, while soil pH, elutriable particles and net precipitation showed negative linear relationships. In conclusion, soil parameters, atmospheric temperature and net precipitation were found to be important parameters for AMNS estimations of grasslands on peat soils. However, further model improvements are necessary to make the model suitable for improved N fertiliser recommendations.

ANALYSIS OF CO_2 EMISSIONS FROM AGRICULTURAL SOILS AND MACHINERIES UNDER DIFFERENT TILLAGE SYSTEMS IN MAIZE

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Tillage can play a very important role in climate change. The intensity of soil carbon dioxide emissions, which contribute to the greenhouse effect, can vary depending on the following factors: the tillage system used, meteorological conditions, soil properties, plant residue characteristics and other factors. The main purpose of this research was to analyse and assess the effects of autumn tillage systems with different intensities on CO2 emissions from soils and from machineries under the climatic conditions of Lithuania. The research was conducted at the Experimental Station of Aleksandras Stulginskis University from 2009 to 2014. The investigations were conducted using five tillage systems in maize: deep ploughing (DP) (depth 230–250 mm), shallow ploughing (SP) (120–150 mm), deep chiselling (DC) (250–300 mm), and shallow cultivation (SC) (120–150 mm). The fifth system was a no-tillage (NT) system. Long-term investigations regarding the dynamics of CO2 emissions from soils during the maize vegetation period indicated that autumn tillage systems affect the total soil CO2 emissions. The highest (2.17 µmol m-2 s-1) soil CO2 emissions during the vegetation period were observed in the DP tillage system, and the lowest values were observed (1.59 µmol m-2 s-1) in the NT system. The assessment of the fuel inputs for these systems revealed that the greatest amount of diesel fuel (67.2 l ha-1) was used in the DP system. The reduced tillage systems required 12–58% less fuel. Lower fuel consumption reduces the costs of technological operations and reduces CO2 emissions, which are associated with the greenhouse effect. The agricultural machinery used in reduced tillage technologies emits 107–223 kg ha-1 of CO2 gas into the environment, whereas DP emits 253 kg ha-1 of CO2.

Poster sessions

Theme 1

Governance and Policy – Posters

INSPIRATION: THE IMPLEMENTATION OF A STRATEGIC RESEARCH AGENDA FOR SPATIAL PLANNING, LAND USE AND SOIL SYSTEMS MANAGEMENT

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The H2020-project INSPIRATION recently presented its June 2017 Green Paper edition of the Europeans' Strategic Research Agenda for integrated spatial planning, land use and soil-sediment-water management. This green paper contains preliminary research proposals published in order to stimulate discussion, refinement and to inspire conversations with potential funders during the match-making phase of INSPIRATION in the second half of 2017.

Land and soil, including water and sediment, play a vital role in meeting societal needs for food, drinking water, energy, shelter, infrastructure and overcoming societal challenges of climate change, non-renewable natural resources and environmental (in)justice. INSPIRATION recognises the interaction between the supply of, and societal demands on natural capital that is created by land-use management practices whose net impact is insufficiently understood.

This agenda describes research and innovation needs as identified in a bottom-up approach by over 500 stakeholders from across Europe, from both the public and private sector at different scales, including citizen groups and NGOs.

The agenda is designed to attract research funding as well as to ensure that knowledge is widely applied by all parties wishing to innovate and contribute to a greener, more socially cohesive, smarter and more competitive Europe.

The European Commission and several European countries seek to put the 17 United Nations Sustainable Development Goals published in 2015 at the heart of their policy frameworks, priorities and budgets. The stakeholder-driven research demands presented in this agenda map on to the SDGs. Researching these topics will enable the Commission and individual countries achieve these goals.

The agenda is particularly intended to be used by research funders to identify research activities they would like to collaborate in common international calls for research. Transnational co-funding is key to creating synergies for organisations wishing to invest in research activities.

Background information on INSPIRATION is available at www.inspiration-h2020.eu and www.inspiration-agenda.eu.

FUNCTIONAL LAND MANAGEMENT: EU AND BRAZIL INTERCONTINENTAL LEARNING – A COMPARISON OF THE SCALES OF ACTION AND ACTORS IN LANDSCAPE MANAGEMENT

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Functional Land Management, launched at the first Wageningen Soil Conference in 2011, is designed as a coherent policy support framework to optimise the returns from the land through sustainable use of Europe's soil resource. LANDMARK, an EU Horizon 2020 project, is quantifying the *supply* of soil functions across Europe, determined by soil properties, land use and soil management practices. At the Wageningen Soil Conference in 2015, we showed how contrasting *demands* framed as EU policies may apply at very different scales from farm-to-European scale.

A key tenet of Functional Land Management is that it can support optimised governance of the soil resource and related soil functions into the future. Farmers/others responsible for the delivery of soil functions exist as part of a wider network. Decisions related to soil are primarily made at a local/farm scale; however institutional arrangements and actors at multiple scales exert influence on such decision-making. Building on the Xingu project in Brazil, we develop and compare a landscape analysis of EU institutional arrangements to structure the connection between plans/programmes and local action. This allows the transformative potential of programmes on the landscape to be better understood. As in the work in Brazil, we similarly map the social actors along with the scales of action to understand networks and their interactions, i.e. who interacts and how. This allows both the role of different actors and the role of relationships/networks in the delivery of soil functions to be identified and assessed. Importantly, we elucidate entry points for action, which may have potential to facilitate more efficicent/effective uptake of existing or new policies. Initial findings indicate that in Brazil, environmental NGOs are key actors with the municipality as the main partner, whereas in the EU, most farmers do business at a local level, but avail of national programmes.

The work is part of the LANDMARK (LAND Management: Assessment, Research, Knowledge Base) project, funded by the EU's Horizon 2020 research and innovation programme under grant agreement No 63521.

SOIL SERVICES IN THE ATLAS NATURAL CAPITAL OF THE NETHERLANDS

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The Atlas Natural Capital (ANK) offers citizens, companies and governments a digital portal to information on ecosystems services and natural capital in the Netherlands (www.atlasnatuurlijkkapitaal.nl). This is part of the national contribution to implement action 5 of the EU Biodiversity Strategy to 2020, and the Dutch policy on the sustainable use of natural capital and ecosystem services in the circular economy. The sustainable use of the environment is also a major focus in the future Environment Act (planned for 2019), besides the current environment policy with an orientation on protection and recovery.

Soil is an important compartment and provides a large set of often-unrecognized ecosystems services. For instance, through vital soils we produce high quality and quantity of food and clean drinking water. Vital soils are furthermore involved in many regulating ecosystem services, like climate regulation, water regulation and natural attenuation. Finally, vital soils harbor a large biodiversity of soil organisms.

The ANK contains information in maps and texts on many soil-related ecosystem services. To date, about 20 soil maps are available in the atlas of 170 maps in total. These maps were produced using data from several soil monitoring programs. The information and maps can be used for land management decisions and spatial planning, from the local to the national scale. The soil maps additionally raise awareness on the multifaceted role of soils in our daily life.

We will present several maps, the data and models behind, and the opportunities this information provide to stakeholders, i.e. those who potentially receive benefits from the natural capital. These maps can also contribute to the discussions on how to map and assess soil-related ecosystem services, which is the objective of the international EU working group MAES (Mapping and Assessment of Ecosystems and their Services). The current national and international attention on the sustainable management of the natural capital accelerates (the need for) practical tools, such as the ANK.

STUDY OF EROSION CONTROL MEASURES IN THE CZECH REPUBLIC

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For the study of erosion control measures of soils in the Czech Republic, the systems of soil categorization were used that contain the main specific features of individual groups of soils. Condition of agriculture farms for the study represent real plants on individual pieces of land in the Czech Republic. Categorization of soil-climatic conditions provides sufficiently accurate definition of the soil productivity level for individual commodities and the need for production inputs. Crop yields and soil inputs were assigned to individual crops by the use of statistical methods based on the main parameters: soil texture, level of fertilization, weather and climate history, soil depth, slope, stoniness, exposure, technological way of tillage and other specific habitat-related conditions that are defined by the categorization of soil-climatic characteristics using so-called valued soil-ecological units (BPEJ). The level of individual yields and costs is attached to each of the main crops that are arranged according to their suitability to individual habitat-related conditions. Production costs are derived from the soil inputs according to operational surveys, applied processes and machinery costs in comparison between standard technology and specialised technology on the slope. Farmers' costs associated with the implementation of measures under GAEC 5 for erosion control measures at the Czech Republic level were evaluated at CZK 5.3 million EUR per year. These costs are compared to the production without limitation of production according to the average composition of crops according to BPEJ registered in LPIS and in accordance with the overall balance of revenues and costs in accordance with the ÚZEI cost survey. These costs are the cost of specialized crop erosion control technology and the resulting losses due to the omission of broad-line crops in the crops. In this case, the broad-field crop areas were replaced by the average of the remaining crops on BPEJ.

Theme 2

Climate change - Posters

THE CHANGES OF CARBON AMOUNT OF SOIL AND RICE PLANT BY KINDS OF DIFFERENT GREEN MANURE CROPS

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A green manure crop were used in many ways such as reduction of chemical fertilizer, physical and chemical characteristic improvement on soils, protection from soil loss, and creating landscape when it's grown in agricultural land. Experiments were conducted to find out carbon emitted by application of green manure crops to agricultural lands in rice-green manure crop cropping system.

The amount of carbon absorbed by green manure crops the winter was 1.22 in hairy vetch, 1,24 tons in barley, and 1.54 tons in hairy vetch/barley. The soil carbon content was the highest at days before transplanting of rice and decreased after that until harvesting time. By the kind of green manure crops, hairy vetch and barley treatment was higher than hairy vetch/barley treatment. The amount of emitted methane was highest at 7 days after transplanting of rice, and was 17 ~ 25 times higher in green manure application treatments than chemical fertilizer. By the kind of green manure crops, hairy vetch was highest, and hairy vetch/barley was next, barley was the lowest. The absorbed amount of carbon on rice plant has been increased during the cultivation period and showed no difference by the kind of green manure crops. The yield of rough rice and rice straw was 5 ~ 13% higher in green manure treatments than chemical fertilizer, and was especially highest in hairy vetch/barley with 14.07 ton per ha.

ADOPTION OF SPRING OILSEED RAPE SOWING TIME AND SOIL TILLAGE TECHNOLOGY IN CHANGING CLIMATE CONDITIONS

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The main reasons for the need to improve the spring oilseed rape growing technology are adaptation to the changing climate and implementation of innovative soil tillage technologies using advanced agricultural machinery. Optimal spring oilseed rape sowing time ensures effective plant protection and better yield formation conditions. These technological innovations reduce spring oilseed rape production costs and environmental pollution. The objective of this research was to estimate optimal sowing time and soil tillage system for spring oilseed rape to ensure a stable and competitive seed yields in changing climate conditions, reducing production costs and impact on the environment. Field experiments were carried out in 2015–2016 at Experimental Station (54º52′ N, 23º49′ E) of Aleksandras Stulginskis University (Lithuania) on Calc(ar)i-Endohypogleyic Luvisol. Treatments of the experiment: Factor A: sowing time (from 10th of April till 25th of May). Factor B: soil tillage method (conventional and no-till). It was estimated that sowing time had significant effect on crop density, but the influence of soil tillage was not significant. There were no significant effect of soil tillage method on soil structure, shear stress and soil bulk density, but soil compaction was higher ($P \leq 0.05$) in no-tillage technology. Total porosity in different soil tillage technologies was not significantly different, but aeration porosity in conventional tillage technology was higher ($P \leq 0.05$). Sowing time and soil tillage methods had a significant influence on spring oilseed rape yields. The highest yield was of the spring oilseed rape sown at the earliest date (10th April) and at the beginning of May (5th and 10th). Higher yields of spring oilseed rape were in conventional tillage technology to compare with no-till. The assessment of the costs for growing and revenues for the harvest showed that conventional tillage is more profitable, but CO2 emissions are by 27.67% lower in no-till.

BIOGEOCHEMISTRY OF OLD ANOGEISSUS GROVES IN THE MOLE NATIONAL PARK OF GHANA

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The study reports soil carbon stock and nutrients characteristics of Anogeissus groves, believed to be associated with old village sites (N 09.337, 001.958 W) abandoned since 1870 in the Mole National Park located in the Guinea Savanna Zone of Ghana. We compared soil nutrient status of the groves and surrounding areas in 2016 with levels reported in an earlier study in the groves by Sobey in 1978. Soil carbon stock of the groves were higher than that of the surrounding savanna landscape (34.71 Mg/ha and 20.74 Mg/ha respectively in the surface soil of 0-14 cm) and with soil total nitrogen, microbial quotients, available nitrogen (NH4+ and NO3-), available phosphorus, exchangeable basic cations, pH and soil moisture all similarly higher in the grove than the surrounding savanna. It also appears that the groves are not in a steady-state with respect to soil organic matter, total and available phosphorus. As example, soil available phosphorus concentration of the groves in 2016 was 203 mg/kg soil compared to a lower level of 133 mg/kg soil in 1978 indicating a percentage increase of 53% over the 38 year lapse. There was a marginal increase in soil exchangeable magnesium levels in both the groves and the surrounding savanna over levels recorded in 1978. Whilst there was no observable increase in exchangeable K concentration in the grove over the period, levels of soil total nitrogen have declined by 25%. Soil nutrient status of the groves and the savanna were markedly higher than nutrients composition of a reference farmland at the erstwhile Damongo State Farm within the Guinea Savanna Zone. The foliar nutrients concentrations (N, P, K, etc.) of the grove's dominant tree species (Anogeissus leiocarpus) were higher than the few Anogeissus in the surrounding multi – species stand savanna. The comparatively higher soil carbon stocks and nutrients content of the groves showed persistence of soil traits initiated through anthropogenic activities in the 19th century, perpetuated and improved through better nutrients cycling mechanisms.

STABILIZED NITROGEN FERTILIZERS AND THE EMISSION OF CO2-C OF A TROPICAL SOIL

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Fertilizers with urease inhibitors are an alternative to reduce NH_3 losses by volatilization when compared to urea. However, little is known about the effect of these fertilizers on microbial activity and the emission of CO_2-C from tropical soils. The objective of this study was to evaluate the effect of fertilizers with urease inhibitors on the CO_2-C emission of a Red-Yellow Oxisol. The experiment followed a 3x5 factorial design in a completely randomized block design with 3 replications. Factor 1 was composed of 3 sources (Urea, Super N and Nitro Mais) and factor 2 of 5 doses (85, 117, 160, 203 and 245 mg of N). The CO_2 emission was evaluated at 1, 3, 7, 11, 15 and 31 days after fertilizer application using the portable automated system of the CO_2 flow of soil LI-COR (LI-8100) Nebraska USA. The highest microbial activity occurred at 3 days after the application of Urea and Nitro Mais and at 7 days for Super N. At these peaks, the mean CO_2 efflux was 7.6; 7.5 and 2.2 μmol m^{-2} s^{-1} for Urea, Nitro Mais and Super N, respectively. These data demonstrate that the NBPT active principle present in Super N reduces microbial activity and the CO_2-C emission of the soil.

EFFECT OF COMPOSTED MANURE APPLICATION ON GREENHOUSE GAS INTENSITIES AND SOIL CARBON IN CORNFIELD: A 3-YEAR FIELD STUDY IN AN ANDOSOL SOIL

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A 3-year study was conducted to evaluate how manure application affects net global warming potential (GWP; the sum of nitrous oxide (N_2O) and methane (CH_4) minus net ecosystem carbon balance (NECB)) and greenhouse gas intensity (GHGI; net GWP per unit of plant biomass produced). In experiment 1, conducted from 2010-2012, 5 treatments namely; control plot (CT), inorganic fertilizer only plot (F), two plots with inorganic fertilizer plus manure (MF1 and MF2), and manure only plot (M) were established. In experiment 2 manure was applied in autumn 2012 and the field was subdivided into 3 plots in spring 2013, with one plot receiving additional manure (MM plot), the second plot received additional inorganic fertilizer (MF) and the third plot did not receive any additional fertilization (M1). N_2O, CH_4 and CO_2 fluxes were measured using static closed chambers. NECB was calculated as carbon (C) inputs minus C output (where a negative value indicates net C loss). In experiment 1, manure application significantly increased NECB and reduced net GWP by more than 30%. GHGI in the manure-amended plots was lower than other plots except in 2012 when the M plot had higher GHGI than F plot. Application of inorganic fertilizer alone increased GWP by 5 and 20% in 2010 and 2011, but showed a 30% reduction in 2012 relative to CT plot. However due to higher net primary production (NPP), F plot had lower GHGI compared to CT. Application of inorganic fertilizer together with manure showed the greatest potential to reduce GWP and GHGI, while increasing NPP and NECB. In experiment 2, additional manure or inorganic fertilizer application in spring increased NPP by similar amount, but additional manure application also increased NECB, and decreased GWP and GHGI. Manure application, as a partial substitute or supplemental fertilizer, shows potential to mitigate GWP and GHGI.

PHOTODEGRADATION PROCESSES IN DRYLANDS: CASE STUDIES IN SOUTH EUROPE AND WESTERN AUSTRALIA

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Despite low annual rainfall and microbial activity, unexplained high rates of litter decomposition, net nitrogen mineralization, soil enzymatic activity and carbon turnover have been observed in arid ecosystems. These observations have been partly explained by photodegradation, a process that consists of the breakdown of organic matter via solar radiation (UV) and that can increase decomposition rates and lead to changes in the balance of carbon and nutrients between plants, soil and atmosphere. In this research, we conducted a multi-site field experiment to test the effects of photodegradation on decomposition of organic amendments used in land restoration. The study was carried out during 12 months in two study areas: the Pilbara region in Western Australia and the Cabo de Gata-Nijar Natural Park, South Spain. Different organic amendments (native mulch versus compost) and soil substrates were used at each site according to local practices. At the two locations, a radiometer and a logger with a soil temperature and soil moisture probe were installed to monitor UV radiation and soil conditions for the duration of the trial. Soil microbial activity, soil CO2 efflux, and the organic matter fractions (including total OC and hydro-soluble C) were measured repeatedly during the experiment. At the end of the experiment, levels of the soluble fraction of C, soil CO2 efflux and soil microbial activity were significantly ($p< 0.05$) higher in those plots amended in the surface in both sites. These increases in the surface reflect a fast C decomposing process that can be directly related to UV radiation, evidencing the critical role of photodegradation on the decomposition of the organic matter. These processes can be critical at global scales as they can contribute to forcing biogeochemical cycles; however, responses will vary depending on the type of the substrate and organic amendment.

THE PERIODICAL CHANGES OF SOIL CARBON ACCORDING TO MORPHOLOGICAL CHARACTERISTICS WITH SEVERAL KINDS OF ORGANIC MATERIAL

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Organic matter is very important in soil ecosystem, especially agricultural land, with several aspects such as carbon and nitrogen cycles. Recently, concerning about climate change, carbon sequestration in agricultural land has become one of the most interesting and debating issues. It should be necessary to understand carbon decomposition pattern about the kinds of organic matter sources to cope with well.

In order to evaluate decomposition of soil carbon according to organic material during cultivating rice in paddy field, we carried out to treat organic material such as hairy vetch, rice straw, oil cake fertilizer, and animal compost at 50 x 50 x 20 cm blocks made of wood board, and analyze carbon contents of fulvic acid and humic acid fraction, and total carbon periodically. The experiment was conducted in 2013-2014, and sampled with interval in a month. The organic material was applied to treatment blocks in 2 weeks ago in rice transplanting of each year.

The treatment of animal compost increased the highest among the treatments about the changes of total carbon showed 7.9 g kg^{-1} May in 2013 to 11.6 g kg^{-1} October in 2014. The carbon as fulvic acid fraction which is considered to easily decompose has been showed fluctuation ranged from 1 to 2 g kg^{-1}. As result as analyzing changes of carbon as humic acid fraction, it was changed between about 1 to 3 g kg^{-1} in all treatments until organic treat had been applied at second in 2014. From May second year application to August, the contents of humic acid fraction carbon has increased to about 4 g kg^{-1}. The average of humic fraction carbon at treatments of animal compost was recorded highest among treatments during two years, showed 2.1 g kg^{-1}. The treat of animal compost has showed the lowest ratio of fulvic acid fraction, humic acid fraction among other treatments even though the amount of their ratio has been different according to time and treatments. The average of ratio of fulvic fraction carbon among all treatments in soil ranged about 16 to 20%, and ration of humic fraction carbon were about 19 to 22%.

In conclusion, animal compost included wood as bulking agent is superior to sequestrate carbon at agricultural land than other kinds of raw plant residue.

Key words: soil organic carbon, decomposition, carbon sequestration, humic substance, hairy vetch, rice straw, oil cake fertilizer, animal compost

CHERNOZEMS CO2 EMISSION VS. SOIL MICROBIAL RESPIRATION

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Soil CO_2 emission is mainly resulted from soil microbial respiration and transfer CO_2 from soil profile. The study was focused on the estimation of relationship between Chernozems CO_2 emission from surface (EM_{surf}), subsoil layers (EM_{10} and EM_{20}, upper two 10 cm consistently removed) and soil basal (microbial) respiration (BR) in forest, steppe, bare fallow and urban ecosystems (Kursk region, Russia: 51°33′-51°39′N/36°04′-36°07′E). EM_{surf}, EM_{10} and EM_{20} of each ecosystem were measured (LI-820) monthly from May to October 2015. Soil temperature (T) and moisture (W) were registered in 0-10, 10-20, 20-30 cm layers, from which soil samples were taken for measuring BR and microbial biomass carbon (MBC) content.

Chernozems EM_{surf} ranged from 2.0 to 35.8 g CO_2 m^{-2} d^{-1} for studied time, for steppe, forest, urban and fallow it was on average 23.8, 15.0, 15.3 and 3.7 g CO_2 m^{-2} d^{-1}, respectively. Soil EM_{10} and EM_{20} of forest and urban was on average 64-123% higher than corresponding EM_{surf}, that of fallow was not significantly differ, and steppe was even by 30-36% lower. The MBC and BR values of Chernozems (0-10 cm) for studied time were varied 284-2710 µg C g^{-1} and 0.28-1.67 µg C-CO_2 g^{-1} h^{-1}, respectively, in forest and steppe they were on average 2-5 times higher than fallow and urban.

The EM_{surf} of various Chernozems ecosystems for six months was significantly correlated with EM_{10}, EM_{20}, W_{0-10}, BR_{0-10} and MBC_{0-10} (r=0.71, 0.53, 0.48, 0.58 and 0.49, respectively). However, for the warmest months ($T_{0-10}\geq12$°C, October excluded) the correlation between EM_{surf} and BR_{0-10}, EM_{surf} and MBC_{0-10} was stronger (r=0.76 and 0.56, respectively). The equation of multiple linear regression was obtained: $\log EM_{surf}=0.88\log BR_{0-10}+0.27\log EM_{10}+0.02W_{0-10}-0.18$ ($R^2=0.74$, $p<0.001$). Thus, Chernozems EM_{surf} of various ecosystems ($T_{0-10}\geq12$°C) was mainly determined by BR_{0-10} and EM_{10}.

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THE ROLE OF SOIL VARIATION IN NUTRIENT BALANCE MODELLING ON DAIRY FARMS

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The Annual Nutrient Cycle Assessment (ANCA, in Dutch: 'Kringloopwijzer') calculates nitrogen (N) and phosphorus (P) balances for Dutch dairy farms, to estimate N and P losses to the environment. Gaseous emissions (N), leaching, run-off and accumulation or depletion of soil N and P stocks are calculated. All calculations are performed at farm level and not at field level, as ANCA uses averaged nutrient inputs and outputs across all fields, and therefore it excludes field-specific soil characteristics. Land management, however, is field-specific and determined by crop and soil characteristics. For an accurate estimate of on-farm nutrient flows, using the appropriate spatial scale of nutrient inputs and outputs is likely imperative to account for soil variation. Our aim was therefore to analyse the impact of soil variation in the assessment of nutrient balances at the farm and field level. We selected five dairy farms in the Netherlands that varied in soil types and the degree of within-farm soil variation. A full year of N and P input and output data on farm and field level were provided by the farmers, while soil variation was determined using the Dutch 1:50.000 soil map. N and P balances were calculated at farm level using ANCA, and calculated at field level using field-specific input and output data provided by the farmers. Nutrient balances at the field level were aggregated to the farm level and compared to ANCA at farm level, focussing on N emissions, leaching and nutrient use efficiency. We discuss the importance of spatial scale in nutrient balance analysis in relation to within-farm soil variation. This study highlights to which extent within-farm soil variation should be taken into account when modelling nutrient flows and nutrient use efficiencies at farm level, to contribute to field-based decision making for improved land management and sustainable food production.

Theme 3

Water resources - Posters

EFFECT OF SUPER ABSORBENT POLYMERS (SAPS) ON THE GROWTH AND YIELD OF LETTUCE (LACTUCA SATIVA) IN DRY CONDITIONS TO PROTECT WATER RESOURCES

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The lack of water is an important global issue which is a challenge to food security and sustainable agriculture. Improvement of agricultural methods to reduce water usage in the fields is a considerable manner for water saving specially in dry regions. Super absorbent polymers (SAPs), a water saving materials, have been applied in agriculture due to their impact on improvement of soil conditions (reduce soil penetration resistance, increase soil water holding capacity and soil aggregation and protection of soil organic matters), and reducing water consumption in the field. The aim of current study is to investigate the effect of super absorbent polymerA200 on the growth and yield of lettuce in dry conditions. In this study, five treatments of SAPA200 (0, 200, 400, 600 and 800 kg/ha) were imposed in a randomized complete block design (RCBD) with three replications. The SAPA200 were applied one week after transplanting of the lettuce seedlings (two leaves stage) at a depth of 10-15 cm of the soil. The structure of soil was determined as sandy loam and the irrigation intervals were two times per week for all of the treatments. After 6 weeks, fresh weight of harvestable head, roots and shoots dry weight and longest root length were measured. The results of the experiments showed that the highest yield (270 gr/head) was achieved in 600 kg/ha SAPA200 compared to the control (60 gr/head). The highest (35%) and lowest (25%) roots dry weight were measured in 800 kg/ha SAPA200 and the control respectively. The longest (24 cm) and shortest (17 cm) root lengths were monitored in the control and 800 kg/ha SAPA200 respectively. The difference between leaves dry weight was not statistically significant. In conclusion, application of SAPA200 improved the yield of lettuce and it can protect water resources and lead to a more sustainable agriculture.

NITROGEN LEACHING FROM ORGANICALLY AMENDED SOILS – AN EXPERIMENTAL APPROACH

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Nitrogen leaching from agricultural soils is a key environmental and economic issue for the assurance of sustainability of agricultural systems. Agricultural practices, such as the use of cattle manure and green manure have been promoted as being environmentally friendly and beneficial for soil nitrogen regime. The behaviour of nitrogen in arable soil is complex and it is not clear how much nitrogen can be lost from arable fertilized soils and what kind of factors affect this process. The objective of our study was to quantify the amount of nitrogen lost from two kinds of soils (Chernozem and Luvisol), which was amended with cattle manure and mustard. We conducted mezocosm experiments in plastic pots buried in soil and kept under natural climatic conditions. Three different treatments were prepared for two different soils: soil without any organic input (control), soil with cattle manure (200 kg N/ha)(CM treatment) and soil with mustard (200 kg N/ha) (M treatment). In all treatment pots, wheat was seeded and grown during the experiments. After the rainy periods, the leachate was collected and analysed for N-NO_3 and N-NH_4 using a SkalarSan^{++} continuous flow analyser system. During spring, two rainy periods allowed the collection of 3.5 - 7 litters of leachate in each pot. The obtained results indicated high nitrogen lost after first sample collection with highest amount of nitrogen lost in Luvisol then in Chernosem. The highest amount of leached nitrogen was measured in cattle manure amended soil (51.85 mgN/l) for Luvisol while for Chernosem the highest amount of nitrogen lost was measured in case of the mustard treatment (30.66 mgN/l). It is known that large amounts of nitrogen can be lost from chemically fertilized soils, but our results indicate that this process also happens in organically fertilized soils, especially during the first part of spring, when rains and low plant development favour this process.

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DEDUCTION OF SOIL HYDRAULIC PARAMETERS TO IMPROVE CAPACITY OF HYDROLOGICAL MODEL USE FOR AGRICULTURAL WATER MANAGEMENT

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Optimal water use in agriculture is become increasingly important, especially with the perspective of global warming. Hydrological models are now commonly used for precise use of agricultural resources. However, one of problems associated with using such models is the uncertainty of model parameters, which often leads to unsatisfactory results of model predictions. In this study, we devised a rigorous approach to deduce soil hydraulic parameters by combining the SWMS-2D software and the genetic algorithm. The field experiments were carried out on 5-year old Jujube trees (Ziziphus jujube cv. Junzao) planted in Xinjiang Province, China (80°30′N, 40°22′E). Surface drip irrigation experiments were conducted in 2012 and 2013, respectively. Three diameters of water-conducting devices of 50 mm, 75 mm and 90 mm were used for three irrigation levels in 2012 (9 L/plant, 13 L/plant, and 17 L/plant), and in 2013 (9 L/plant, 14 L/plant, and 19 L/plant). In each treatment soil samples in 15 different locations were taken for moisture measurement before and after irrigation. The results from the 2012 experiments (calibration case) were used for inferring soil hydraulic parameters and those from the 2013 experiments were used as an independent dataset for model validation (validation case). Three indices were used for assessing model predictions: the Nash–Sutcliffe efficiency (NSE), the root of the mean squared errors (RMSE) and the mean error (ME). It has been shown that the values of NSE, RMSE and ME for the calibration case were 0.768, 0.014 cm3 cm-3 and 0.006 cm3 cm-3, while the corresponding values for the validation case were 0.771, 0.014 cm3 cm-3 and 0.006 cm3 cm-3, respectively. This indicates that the approach employed in deducing the soil hydraulic parameters were reliable, and the model calibrated in this way could be used for agricultural water management in the region.

Theme 4

Land functions - Posters

TIME-DEPENDENT EFFECT OF COMPOSTED TANNERY SLUDGE ON THE CHEMICAL AND MICROBIAL PROPERTIES OF SOIL

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Composting has been reported to be an efficient method for tannery sludge recycling before its application to the soil. However, the application of composted tannery sludge (CTS) to the soil should be monitored to evaluate its effect on the chemical and microbial properties of soil. This study evaluated the time-dependent effect of CTS on the chemical and microbial properties of soil. CTS was applied at 0, 2.5, 5, 10, and 20 ton ha^{-1} and the chemical and microbial properties of soil were evaluated at 0, 45, 75, 150, and 180 days. CTS rates and sampling times had a significant influence on the properties of the soil. The values of soil pH, organic C, P, Ca, Mg, and Cr increased with increased CTS rates and decreased over time. Similarly, soil microbial biomass, β-glucosidase, phosphatase and dehydrogenase increased with the application of CTS and decreased over time. Analysis of the Principal Response Curve (PRC) showed a significant effect of CTS rate on soil microbial properties over time, with a positive correlation between the height of the CTS rate and the response of the chemical and microbial properties of soil. In conclusion, CTS application influences the chemical and microbial properties of soil differently over time; and, Cr, pH, Ca, phosphatase, and soil respiration were variables that were more strongly affected after CTS application.

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PLASTIC MULCH DEBRIS IMPACT ON SOIL PROPERTIES

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Plastic mulch is commonly used in agriculture for several purposes such as keeping the water moisture, warming up the soil, preventing weeds or limiting soil erosion. After harvesting these films happen to be torn apart and incorporated to the soil by ploughing. However the impact of plastic debris on the soil physical properties is not well known.

We conducted a laboratory mesocosm experiment with sandy soil mixed with different plastics to study their effect on soil properties. Therefore, we used two types of plastic, low density polyethylene (LDPE) which is commonly used as plastic film and a biodegradable plastic made of Polyethylene Terephthalate (PET), Polybutylene Terephthalate (PBT) and Pullulan. Two different sizes of plastic fragments, $5*5\ mm^2$ pieces and powder from 50 µm to 1 mm were applied in 0.5% concentrations. Similar concentrations were detected in Chinese agricultural topsoil samples. Measurements were done one month after on ring samples. We tested the effects of the different treatments on dry bulk density, porosity, saturated hydraulic conductivity, aggregation stability index, electrical conductivity, pH retention curve and water drop penetration time (WDPT). Preliminary results for these three last parameters show significant changes of soil physical properties depending on types and size of plastics debris.

These modifications of soil physical properties might impact the plant growth. Further studies are required to see the effect of these debris on plant production.

SOIL PHYSICAL AND HYDRAULIC PROPERTIES OF 'FOREST ISLANDS' AND ADJACENT ECOSYSTEM TYPES IN WEST AFRICA

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Understanding the functioning and soil dynamics of forest islands in West Africa should assist in the development of sustainable management of such ecosystems in the region. However, very little information exists on the physical and hydraulic properties of these ecosystems created through anthropogenic activities and preserved by local populations in an open savanna landscape. The objective of this study was therefore to evaluate the physical properties (aggregate stability, bulk density, etc.) and hydraulic properties (soil moisture, hydraulic conductivity, etc.) of forest islands in West Africa as compared to those of adjacent savannas and agroecosystems. The study was conducted in Ghana, Nigeria and Burkina Faso with three sites located in three different agro-ecological zones of the latter (Burkina Faso). Soil moisture was measured weekly using the neutron probe. Data on soil moisture in 2016 at the three sites (Dano, Houndé and Boromotenga) in Burkina Faso showed significant differences between sites. The highest soil moisture (75 m^3m^{-3}) was recorded at Dano whilst the lowest (43 m^3 m^{-3}) was observed at Houndé with a clear difference between the ecosystems types at all locations. Specifically, regardless of season, location or horizon, soil moisture was lower in forest islands compared to natural forests and croplands. Upper soil horizons in the upper 0.4 m are relatively depleted in soil moisture compared to the lower soil horizons.

SOIL TEXTURE ANALYSIS BY LASER DIFFRACTION – STANDARDISATION NEEDED

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Subtitle: How widespread and important is: 1) Under reporting of pretreatment method, 2) Uncertainty caused by small sample size, 3) Need for translation of old PTF's based on sieving and sedimentation methods, 4) Lack of awareness in literature?

Soil texture is a key soil physical property for soil quality and used in modeling studies through pedotransfer functions (PTF) for the prediction of physical, e.g. hydraulic, soil properties. Soil texture is quantified by a particle size distribution (PSD) of the fine earth fraction and often translated into a texture class using defined separates of clay (0 - 2 µm), silt (2 µm to 20 µm, 50 µm or 63 µm) and sand (20 µm, 50 µm or 63 µm up to 2 mm) illustrated in a texture triangle.

Until now pretreatment methods (e.g. humus and carbonate removal and dispersion) followed by standardised sedimentation and sieving methods have been well-defined. From literature and a mini-survey, we know already that laser diffraction is a commonly used analytical method for soil PSD determination in scientific environmental studies that involve soils. A body of literature has documented that colloid-sized fraction results obtained by laser diffraction analysis of fine-textured soil samples are not comparable to those obtained with sedimentation and sieving methods, when translating to the traditional particle size limits clay, silt and sand. Also, operating procedures for pretreatment of soil samples are variable, and the analyzed sample volumes are small, adding to uncertainty.

In this study we first compared PSD's from three different instruments for a set of soil samples to study reproducibility using the analytical operating procedures developed by the owner institutions (Malvern Mastersizer 2000, University of Copenhagen, Coulter LS230, University of Helsinki, and Sympatec Helos, Aarhus University). Secondly, we compared the influence of 1 mm sieving and found decreased fraction standard deviation and improved repeatability of the PSD determination by laser diffraction on the Coulter LS230. 1 mm sieving should be corrected for if the mass is more than a few percent, but depending on study purpose. Thirdly, the laser diffraction PSD's were compared with PSD's obtained by sieving and hydrometer analysis showing well-known underestimation of colloids and fine fractions, that increased with colloid content.

We conclude that PSD's obtained by the laser diffraction method are repeatable and mostly reproducible given standardised pretreatment. Translation to texture class using traditional separates does not work well, and more work and new PTF's for soils are needed that can translate a laser diffraction PSD into a texture class and its associated physical properties for further use in modeling studies.

CHANGES WITHIN NEMATODE COMMUNITIES IN WINDTHROWN EUROPEAN MONTANE SPRUCE FORESTS AFTER DISTURBANCE BY FIRE

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This study presented analysis of the soil nematode communities as indicators of soil conditions 8 years after a wildfire in the spruce forest ecosystem of the High Tatra Mountains. Two plots were established, an intact control plot (REF) and a fire-damaged plot after a windstorm (FIR). A total of 20 representative soil samples were collected; 10 from each site (five in June and five in October). A total of 64 species of nematodes were recorded. Total numbers of nematode species and species diversity index remained significantly lower relative to the control site, suggesting an ongoing negative effect of fire on these parameters of nematode assemblage. The population of bacterivorous nematodes remained higher at the burned than the unburned site, likely due to the higher total nematode abundance in response to the higher microbial biomass that developed after the fire. Omnivores were more abundant in FIR than in REF, and predators were more abundant in REF. The total abundance of plant parasites did not change, but ectoparasites of the Criconematidae family occupied only the unburned site. The analyses and comparisons of the soil nematode communities of the burned and unburned sites by various ecological, functional and diversity indices and metabolic footprints suggest that the soil ecosystem 8 years after the fire seems to be recovered with moderate levels of nutrient enrichment comparable to those of the control site.

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SPATIAL PATTERNS OF SOIL CARBON TURNOVER TIMES USING MUTIPLE DATASETS

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Soil organic carbon (SOC) is a crucial component in global carbon cycle. The balance between influx and efflux of carbon together with SOC stock determines land-atmosphere carbon exchange, thus climate. Carbon turnover time, which is defined by the ratio between carbon stock and influx (efflux) assuming steady state, is a dynamic parameter and an ecosystem property that partly determines the feedback between carbon cycle and climate. However, the response of the net fluxes of carbon and carbon stock to climate change and below ground processes is characterized by large uncertainties which has already been showed by ensemble of state-of-the-art models. To reduce the uncertainty in the projected change of carbon cycle to climate change, we aim to gain new estimates of soil carbon stocks and turnover time. We use multiple observational-based datasets to show difference in spatial patterns of soil carbon stock, flux and turnover time and their relationship with climate and nutrient supply. Three sets of soil datasets were used including Harmonized World Soil Database (HWSD), SoilGrids and The Northern Circumpolar Soil Carbon Database (NCSCD). An inconsistency among the soil datasets is that SOC values are represented in different depths, which makes it difficult to compare with each other. To solve the problem we extrapolate the soil profile from surface to full soil depth using multiple empirical models. In order to estimate carbon fluxes on global scale, we used Fluxcom product of GPP for the 1980-2013 period as a result of both machine learning algorithm and process-based land models. The newest version of GPP data is updated from 0.5° to the spatial resolution of 0.083° (10 km). With the availability of the new updated observational datasets we are able to show the spatial patterns and their difference of carbon stocks and turnover time on global scale.

GOOD FOREST PRACTICES AND HEALTHY SOILS. A SOUND ASSOCIATION IN NORTH PATAGONIA, ARGENTINA

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This article addresses "the state of the art" on the knowledge about the effects of *Pinus ponderosa* plantations over natural ecosystems in North Patagonia, Argentina. Organic matter, pH and bulk density are useful soil indicators for monitoring soil health in a forest system. Each of them explains a series of properties that are related with their content or values. In North Patagonia, most afforestations are established on volcanic ash soils, which show a high productivity and, as a result of their unique properties, they respond differently to land use changes, as it would be expected in normal soils. Different studies which compared equivalent sites under natural vegetation and under pine plantation analyzed the effect of the afforestation on soil pH. In forest bio-sequence (*Nothofagus sp*), with udic andisols, this property did not change with land use (difference between means of 0.1 points) with a moderately acid reaction, although it was a drop in pH_{KCl}. Exchangeable bases were less under pine, possibly due to Al^{+3} adsorption and release of bases, avoiding pH_w form descending. This process is common in these highly alofanized and buffered soils. On the other hand, in ecotone steppe bio-sequence, with xeric and poorly alofanized andic mollisols, both pH were more acid under pine (difference between means: 0.2 points), due to their less buffer capacity. In spite of that, they remained in the same acidity class: lightly acid. Total exchangeable bases did not vary, as well as PO_4^{-3} retention. Based on these results, this slight pH descent should not cause relevant variations in soil conditions for germination and growth of native species as well as new afforestations. Bulk density and porosity did not varied, although there was an increase in micro-porosity under pines. Organic matter content (%) was less under pines, although total carbon stored ($tn.ha^{-1}$) is equivalent or higher, because of the role of tree cover in protecting soil from erosion, mainly in overgrazed ecotone areas. Keeping an open canopy through thinning allows an understory to grow, favoring biodiversity on and within the soil and all biogeochemist cycles related to them. Avoiding total forest clearance when harvesting, protects soil from erosion and helps to preserve carbon pool, especially in sloping areas. Monitoring soil indicators is useful to control and correct eventual undesired effects of pine plantations.

SOIL MICROBIAL BIOMASS, MICROBIAL RESPIRATION, FUNGI-TO-BACTERIA RATIO UNDER DIFFERENT LAND USE IN MOSCOW REGION

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Modern land-use change might be affected soil microbial component functioning. The research was focused on the assessment of soil microbial community status in natural, arable (plowing) and urban areas in two districts (Sergiev Posad, Voskresensk) of Moscow region (55°17´-56°26´N, 38°03´-38°43´E). Umbric Albeluvisols of forest, meadow, arable and Technic Umbric Albeluvisols of urban (recreational, industrial) areas were studied. In each land-use type of studied districts the five spatially distributed sites were selected for topsoil sampling (0-10 cm, totally 50). The soil organic carbon (SOC), NPK and heavy metals (HM: Cd, Cu, Ni, Pb, Zn) contents, pH_{KCl}, basal respiration (BR), microbial biomass carbon (MBC) by SIR-method and fungi-to-bacteria (F/B) ratio by selective inhibition technique (3 sites) were measured; MBC/SOC ratios calculated. SOC content varied from 1.5 to 10.3%, it was on average 4.3, 3.0, 3.4, 5.6 and 3.7% for forest, meadow, arable, recreational and industrial areas, respectively. HM and P contents of urban soils were on average 1.2-6.7 times higher natural analogues. MBC of forest, meadow, arable and recreational areas was reached on average 406, 384, 323 and 358 µg C g^{-1}, respectively, however it was on average less for industrial, which amounted 198 µg C g^{-1}. The BR of forest, meadow and recreational areas was 1.4-2.7 times higher than arable and industrial. The MBC/SOC of forest, meadow and arable areas was on average 1.4-2.6 times higher compared to urban, it might be indicated decreasing C-use efficiency in urban locations. The F/B of forest, recreational and industrial areas was 3.8, 3.3 and 1.4, respectively, which indicates decreasing fungi portion under anthropogenic impact.

Thus, it was found some deterioration of soil microbial community functioning under plowing and urbanization, which was expressed in decreasing biomass, respiration activity, fungi portion and C-use efficiency.

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SOIL MINERALOGY OF FOREST ISLANDS OF WEST AFRICA

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Forest islands, defined as patches of forests around villages existing on savanna landscapes as a result of anthropogenic activities, were identified in Burkina Faso (BF), Ghana (GH) and Nigeria (NG). The mechanisms by which forest islands are created seem well established but the mineralogy and biogeochemistry of the phenomenon is yet to be expounded. The study therefore aimed at examining the mineralogy of two forest islands and adjacent croplands in each of the countries. The results showed mineralogical complexity and varying degree of soil weathering among the forest islands and adjacent croplands though with some level of similarities within the sites (countries). Quartz and kaolinites were the most dominant minerals with other minerals such as boehmite, feldspars, hydrogoethite, Mg-rich hornblende, phlogopite and zeolites; varying in type and intensities across the ecosystem types and sites. Navrongo (GH), Koupela (BF) and Wasimi okuta (NG) forest islands are the richest in mineralogical compositions (appreciable quantities of muscovites and smectites), less weathered, and characterized by high pH (except Wasimi okuta). Generally, there is much more considerable mineralogical diversity among the Nigerian soils than there is within any other site. The mineralogical diversity within a particular site (i.e. forest island vs. cropland), where it exists, is usually small but nevertheless real as these data relates with the oral accounts of creation of these forest islands as captured during the fieldwork.

CONTRAST RATIO AS AN IMPORTANT CHARACTERISTIC OF SOILS IN THE NORTHWEST OF THE BLACK SEA REGION

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Contrast ratio - this is one of the major quantitative characteristics of the soil cover structure. Determining the soils contrast ratio is based on the detection of differences (essential and non-essential) between two samples of separate indicators of soil properties.

Obviously, the contrast ratio of soils in the Northwest of the Black Sea region depends on two main factors – the dissected relief and the overlay of processes of slope pedogenesis on the zonal soil evolution. Thus, in the areas with the developed mesorelief, which on the research territory is mostly of the erosional origin, the soil catenas of the erosional-deluvial type are formed.

To detect the soils contrast ratio, we used three groups of soil properties – the morphological parameters, the indicators of humus state and the parameters of the optical properties of humic acids. The contrast ratio detection was conducted with random samples for each indicator separately for each group of soils.

In the process of the soils contrast ratio research in the Northwest of the Black Sea region we have found, that the slope evolution of the soil cover is typical for each of the researched catenas. It runs towards the erosion and xeromorphism strengthening at the higher levels of the slope and the hydromorphism increasing at the lower levels. In turn, in the zonal aspect, the area of research is the transition stripe from gypsic kastanozems to calcic chernozems (pedo-ecotone) in which the soils evolution speed is balanced by the slope processes within local microcatenas. It is determined that the difference in moistening at the different levels of the local catenas resulted in approaching, by the morphological parameters, of more hydromorphic soils to calcic chernozems, and of more xeromorphic soils to gypsic kastanozems. The intensive dehumification caused the levelling of differences between the pedo-ecotone soils by the indicators of the humus state and caused their approaching to gypsic kastanozems.

NEW STRATEGIES IN MINE REHABILITATION: APPLICATION OF CYANOBACTERIA TO ENHANCE SOIL FUNCTIONS

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Despite the large efforts and investments to dryland ecosystems restoration worldwide, land rehabilitation in these areas has very low rates of success. Most of the challenges in landscape-scale restoration come from the lack of suitable soil substrates with adequate seedbank and nutrients to support plant establishment and achieve functional ecosystems. Development of appropriate soil structures such as technosols can be extremely expensive and demanding in terms of time and natural resources soils and therefore new approaches need to be explored. In the last years, the potential of cyanobacteria from soil biological crust to restore soil functionality in degraded lands, has increasingly gained attention because of their important roles in controlling soil structure, preventing soil erosion, and N and C fixation. Nevertheless, many research gaps still remain in their application to restore functionality of reconstructed soils in land rehabilitation programs. In this study, we analysed the potential of cyanobacterial inoculation to restore soil functions, e.g. N fixation, C sequestration, microbial activity, of soil substrates used in post-mine restoration. Soil substrates consisted of original topsoil retrieved from previously stockpiled material, an overburden waste material commonly used in landform reconstruction, and a mixture of both substrates. These materials were collected from an active mine site in the biodiverse and mining intensive Pilbara region (Western Australia), and inoculated with a mixture of cyanobacteria from three nitrogen fixing genera (Nostoc, Scytonema and Tolypothrix). Our results showed that cyanobacteria rapidly colonized the mine substrates, covering more than 45% of the soil surface after three months. During this time, soil organic carbon levels doubled in the waste material, reaching similar levels to topsoil. The output of this research is the first step to effectively address the reconstruction of soil substrates that can provide support to the establishment of biodiverse vegetation communities in landscape-scale mine restoration.

AN ASSESSMENT OF WATER TABLE DEPTH AND WATER QUALITY DYNAMICS IN SALT AFFECTED RICE SOILS OF BHADRA COMMAND, KARNATAKA

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Unscrupulous, indiscriminate and excessive use of irrigation water, particularly in command areas, become a potential source of recharge which caused a continuous rise in water table and degrade the soil with water logging and soil salinization. Hence, a study was carried out during 2013-14 to evaluate the fluctuation in water table and quality of water in water logged and salt affected soils of Bhadra command by installing observation tubes at different topography to determine the extent and nature of water table to recommend suitable drainage design and water management practices to be followed.

The water table monitored in each observation tube at monthly intervals revealed that the water table was deeper (59.15 cm to 136.33 cm) at low land compared to upland and mid land, whereas shallow water table was noticed in midland (46.94 cm to 115.79 cm) reasoning fluctuation in water table to canal water supply and drainage lines. The water quality of observation tubes was alkaline in nature (pH 8.29 to 9.02) irrespective of depth and seasons. Among cations, Na^{+} and Cl^{-1} was the dominant anions noticed in the water.

The water samples collected during summer belong to C_4S_1 category, while the samples of *rabi* and *kharif* belongs to C_3S_1 category. Salinity of water increased slightly with shallower water table (mid lands) compared to up lands and low lands, due to vertical and horizontal seepage of water from surface. This study clearly revealed that in Bhadra command area, unscrupulous heavy irrigation has led to rising of water table to a critical zone of < 1.5 m in rice fields, in addition, neglecting the drainage have also aggravated the situation. The results also showed that the water drained through the soil was saline in nature, hence not suitable for irrigation or for leaching if it is used directly.

Key words: Salt affected soils, water table, observation tubes, water quality.

OCCURRENCE OF MICROPLASTICS IN ARGRICULTURE SOILS OF NORTHWESTERN CHINA

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The application of plastic mulch in agriculture has increased dramatically, and plastic debris after harvesting has become a severe problem in the environment. Microplastics as the fraction of plastics are persistent, bioaccumulated and toxic to non-target organisms in the environment. Although increasing attentions have been aroused for microplastics in the aquatic environment, knowledge of occurrence of microplastics in the soil is scarce. In our study, soil samples were collected from cropland, orchard and greenhouses in Yangling, Baoji and Weinan of Wei River catchment in 2016. Microplastics were extracted and identified by our new developed method (S. Zhang et al. in prep) in all soil samples. The results showed that the frequency of detection was 35.8%. The average numbers of microplastics were 164.2 particles kg^{-1} soil and the particle size ranged from 20 µm to 810 µm. The highest numbers of microplastics per site were 186.7 particles kg^{-1} soil in samples from Baoji, followed by Weinan (179.7 particles kg^{-1}) and Yangling (126.7 particles kg^{-1}). The highest frequency of detection was observed in the samples from Baoji, with 41.7%, followed by Weinan (33.9%) and Yangling (31.7%). The wider particle size range was detected in the samples from Yangling. Regarding to the soil sample taken from different crop cultivation lands, microplastics were detected most frequently in soil samples from greenhouse land, followed by cropland and orchard land in Baoji and Weinan. However, in Yangling, samples from orchard land had the highest frequency of detection and numbers of microplastics comparing with the samples from cropland and greenhouse land. Therefore, further studies should be taken into account to illustrate microplastic effects on soil quality, especially in the area with different crop production.

SOIL NITROGEN AVAILABILITY FOR RICE UNDER CONSERVATION AGRICULTURE SYSTEMS IN THE LAKE ALAOTRA REGION, MADAGASCAR

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Conservation agriculture (CA) has been promoted to overcome low crop productivity in rainfed production systems. Restitution of crop residues on the soil surface and crop rotations contribute to better nutrient cycling and improve soil fertility. These beneficial effects depend on the climate and soil conditions, and on the type of residues.

An experiment was carried out in the Lake Alaotra region, Madagascar during two growing seasons (2013-14 and 2014-15) with respectively 700 and 1000 mm of rain. Soil mineral nitrogen and rice yield were quantified under two treatments of tillage and residue management, a CA system with no tillage and residue retention and a conventional system (CT) with tillage and residue removal, in two crop rotations, a two year rotation of maize + Dolichos lablab and rice (MD), and a three year rotation of maize + Stylosanthes guianensis, Stylosanthes guianensis and rice (MS). Soil nitrogen was measured at five soil depths (0-10, 10-20, 20-30, 30-60, 60-90) during five growth stages of rice (germination, tillering, panicle initiation, flowering, and maturity).The results showed significant differences in soil mineral N (0-30 cm) between CA and CT during 2013-14 with Stylosanthes guinensis residues. An increase in soil mineral N of 45%, 46% and 52% was observed in respectively the 0-10, 10-20 and 20-30 cm soil layers at tillering stage. No differences were observed with maize and Dolichos lablab residues. Rice yield was significantly higher under MS than MD both for CA and CT. During 2014-15 soil mineral N was not affected by tillage treatment and residue type/rotation and rice yield was significantly higher under MS than MD for CA, but not for CT.

CA systems with retention of crop residues from N rich cover crops can improve availability of mineral nitrogen for rice under favourable rainfall conditions, i.e. when leaching losses are relatively low.

DO CACAO AGROFOREST RESEMBLE FOREST? ROOT DENSITY, SOIL MACROPORE AND SOIL INFILTRATION

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Agriculture practices coping with variable rainfall in climate change era need to maintain good soil condition, characterized by a plenty of soil macropores, rapid infiltration and deep root systems in order to increase buffering during dry periods. With appropriate tree combinations and management, agroforestry can provide these functions. The objectives of this research are to investigate whether agroforestry can provide a good soil condition, compared to monoculture (tree and annual crop). We quantified soil parameters in five land use systems (LUS) in Konawe District, Southeast Sulawesi: (1) degraded forest (DF), (2) cacao-complex agroforestry (CAF), (3) cacao-simple agroforestry (SAF), (4) monoculture cacao (CM) and (5) annual food crop (CR) with three replications. Root samples were collected using root trenching method, two root parameters observed were total root length density (Lrv, cm cm^{-3}) and dried root weight (Drv, g cm^{-3}). Soil macropore was quantified through mapping method using Methylene Blue dye, and soil infiltration measured using single ring infiltrometer. The results showed that, LRV in DF (0.15 cm cm^{-3}) was three times higher compared to all agricultural LUS. In first 20 cm of soil, CAF has the higher DRV (0.00094 g cm^{-3}) compared to other agricultural systems (0.00052 g cm^{-3}), however DF still has the highest DRV (0.00242 g cm^{-3}). DF has the highest soil macroporosity (8.2%), followed by CAF (7%), and SAF, CR, CM by (3.2%). Soil infiltration in DF (13.2 cm $hour^{-1}$) were significantly higher than other LUS (6 cm $hour^{-1}$), meanwhile if we focused on agriculture system, agroforestry (CAF and SAF) had a faster soil infiltration (6.6 cm $hour^{-1}$) compared to CM and CR (5.4 cm $hour^{-1}$). Results of this study imply that increasing of root density in complex agroforestry can lead to more soil macropores, however, this is not sufficient to achieve the soil infiltration of remnant forest.

CONSEQUENCES OF UNCERTAINTY IN FIELD OBSERVATIONS OF SOIL DEPTH FOR DIGITAL SOIL MAPPING OF SOIL FUNCTIONS

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Many large soil profile databases are compilations of multiple surveys and include a variation in observation uncertainty. This uncertainty is often unknown and therefore ignored in studies. Question remains how the uncertainty can be derived and incorporated in the subsequent analysis? Over the past 15 years a database of over 1800 georeferenced soil profile observations has been compiled during the WU-SGL Field-training Geosciences course for a 340 km^2 study area in Southern Spain. In this database of site and soil profile observations, effective soil depth was one of the quantitative variables observed by students. However, in what way can we actually assess best the uncertainty of these observations? Secondly, how can we produce the best prediction for soil depth in this study area, using the available explanatory variables and taking observation uncertainty into account? Soil depth in the study area depends a.o. on parent material, slope angle and landscape position. For both the aforementioned questions the knowledge on spatial heterogeneity of the explanatory variables between and within discrete mapping units is crucial. In this study we elaborated on observation uncertainty and recommend which digital soil mapping model yields the best prediction of soil depth in the study area, using the calibrating and validating potential of such a large database. Finally, the impact of soil depth uncertainty on the available water capacity is evaluated for different soil mapping units.

GRANULOMETRIC COMPOSITION AS A PREDICTOR OF PEDOTRANSFER FUNCTIONS: USE OF LASER DIFFRACTION AND SEDIMENTOMETRIC METHODS

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Granulometric composition (or Particle size distribution, PSD) is the main predictor variable used in Pedotransfer functions (PTFs). A specialized database with PSD data is required to justify the PTF. These databases contain of PSD measured by sedimentation methods (pipette, hydrometer, etc). Recently Laser Diffraction Method (LDM) is widely used to ascertain a PSD. There are significant differences between sedimentation and LDM: sedimentation methods determine higher values of PSD fine grain fractions (silt, clay) due to the distribution of the solid phase density in different granulometric fractions and their different origins and composition. In heavy clay soils with high organic matter content, the differences may reach several times that can cause serious errors in the PTF determination and use. The aim of the paper is to validate the use of PSD measured by LDM to estimate soil water and heat flow by using PTFs. Soil saturated hydraulic conductivity (KS), and soil thermal diffusivity (KD) are measured for Umbric Albeluvisols Abruptic (WRB, 2006) by the direct method and by PTFs methods. PTFs are calculated based on PSD measured by LDM and by PM. Saturated hydraulic conductivity (KSPM), (KSLDM), and soil thermal diffusivity (KPM), (KLDM) are obtained by PM and LDM, respectively. The results observed that R2 for KSPM 0.94 and KPM 0.90 were higher than KSLDM 0.855 and KLDM 0.835. However, RMSE for KSLDM 2.4×10-6 and KLDM 9.3×10-8 were lower than KSPM 2.6×10-6 and KPM, 9.98×10-8, respectively. LDM technique is the powerful method for measuring particle size measurement and can be successfully used for estimation hydraulic properties and thermal parameters for Silty Clay loam and lighter soils, using PTFs without any modification or recalculation.

SOIL MONITORING FOR CAP EVALUATION IN POLAND

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Monitoring programs on soils quality including many physical and chemical parameters were conducted on different scales in Poland. However, they were not linked with the evaluation of CAP. In 2014 Ministry of Agriculture and Rural Development had recommended the Institute of Soil Science and Plant Cultivation – State Research Institute elaboration of the methodology for country-wide monitoring programme to evaluate the CAP influence on agricultural soils with respect to implementation of Pillar I and Pillar II. The programme started in 2016 and is aimed to comprehensive assessment of the impact of the CAP implementation in rural areas with particular attention to soil parameters.

Monitoring is planned as a continuous task carried out every 4 years simultaneously at two levels: country to assess predominantly Pillar I and farms for Pillar II evaluation. At country level field work, sample collection and laboratory analysis are implemented. Basic soil characteristics as e.g. pH, organic carbon, cation exchange capacity and exchangeable bases are performed in the cooperation with Chemical and Agricultural Stations. At the farm level physical and chemical analysis are extended by biodiversity measures and the detailed information sheet filled in by farmers. So far over 30 000 soil samples were investigated at the country level and 600 reference farms designated.

Important part of the programme is dedicated to the assessment of the current state of the C-rich soils under pasture with the evaluation of processes influenced their changes. This part of the monitoring includes investigations over 1200 soil profiles which will be compared with the soil information coming from 70's of last century.

The data collected within monitoring can supplement the European and global information database on soil properties and indicate on trends of their changes within time. Moreover, can point valuable indicators for the proper CAP evaluation as regard to soil quality.

CROP YIELD REMEDIES AND SOIL IMPROVEMENTS OF SOIL-COMPACTION-RELIEVING-MEASURES, A META-ANALYSIS

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Abstract

Soil compaction limits the infiltration of water, gas diffusivity, and the penetration of roots and fauna into the (sub)soil. Thereby, soil compaction affects crop growth and yields, biological activity, nutrient transformations, and greenhouse gas emissions. Various measures have been suggested to prevent and/or relieve the effects of soil compaction, such as controlled traffic, tillage, subsoiling, and fertilization, but the effects have not systematically analyzed yet. Here we report on a meta-analysis of the effects of soil compaction alleviation measures. A total of 57 studies in 23 countries with 587 crop yield and soil bulk density/penetration observations have been examined statistically. Results indicate that various measures contribute to alleviate the effects of soil compaction and increase crop yields. Effects of crop rotation and manuring were statistically significant in general, but effects appear to differ between regions and soil types. Measures appear to have greater effects on crop yield in East Asia than in other regions of the world. Measures were more effective in enhancing crop yields in loamy soil than in clay soil and sandy soil. Controlled traffic and manuring significantly decreased the bulk density of both topsoil and subsoil, and in part also the resistance to subsoil penetration. In conclusion, various measures help to alleviate the negative effects of soil compaction on crop yield. More efforts are needed to improve soil structure.

Key words: yield, soil bulk density, soil penetration, alleviation, meta-analysis

SYNERGIES OF MICROPLASTIC AND GLYPHOSATE TRANSPORT IN THE SOIL ECOSYSTEM WITH ERATHWORM GALLERIES: A MESOCOSMS APPROACH

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In China and Latin America, at agricultural areas there is an intense use of plastic mulching which leads to a strong soil plastic pollution and in those areas also glyphosate is applied. Both pollutants may have effects on the burrow formation by earthworms and may have synergistic effects on their biogene transport. Therefore, we studied the biogene transport of glyphosate (1.8 (G1) and 3.6 (G2) kg ha^{-1}) and its main metabolite aminomethylphosphonic acid (AMPA) under the influence of different concentration of microplastics (MPs) (150 µm, light density Polyethylene) (0,1% (MP1),3% (MP3)). For the burrow formation we added the anecic earthworm *Lumbricus terrestris* to sandy soil in this mesocosm experiment. Duration of the experiment was 2 weeks. After 14 days we observed that the treatments with M1G2 showed significant higher production of burrows than all other treatments. The significant larger volume of burrows (17.9±10.2 cm^3, $p<0.05$) were observed at treatment MP3G2 than in all other treatments, which refers to a high activity. Highest contents of glyphosate and AMPA were detected in the surface soil, comparing samples from inside and outside of burrows, with significant differences between treatments G1 and G2. The downward transport of glyphosate only took place in the earthworm burrows but not in the soil outside the burrows showing content near the limit of detection (LOD). Higher contents of glyphosate and AMPA in the burrow walls were detected ranging from 0.05 to 4.3 mg kg^{-1} and <LOD to 0.8 mg kg^{-1}, for glyphosate and AMPA contents, respectively. The variation contents of glyphosate and AMPA in burrow walls were significantly related to the location where burrow was connected with soil surface. The total transport rate of glyphosate (including AMPA) was 9±3%, 12±3%, 10±4%, 13±8% in treatment of MP1G1, MP1G2, MP2G1, MP3G2, respectively.

Theme 5

Biodiversity - Posters

EFFECT OF INSECTICIDES TO SOIL NEMATODE COMMUNITIES IN MAIZE FIELD

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Study assessed the effect of commercial insecticides used for the control of the western corn rootworm (*Diabrotica virgifera* ssp. *virgifera*) on the nematode community. The nematode communities were evaluated in a two-year field experiment in an agricultural field planted with *Zea mays* as well as in a complementary pot experiment. Three different insecticide variants were used in the experiment: a granular application of tefluthrin, seed treatment of clothianidin and granular application of clothianidin.

In total, 39 nematode species and 35 genera were identified in the maize field. A significant impact of season was found on the relative abundance of trophic groups and all ecological and diversity indices, with the exception of nematode abundance. This study concludes that soil nematode communities are very sensitive to climatic conditions or any environmental change. Within the same environmental conditions, it was found that nematode communities were also affected by the chemical control of insects with clothianidin or tefluthrin. For many parameters of nematode communities, the effects of year and sampling date were more pronounced than the effects of insecticide application.

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SOIL BACTERIAL DIVERSITY AFTER EIGHT YEARS OF COMPOSTED TANNERY SLUDGE AMENDMENT

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Composting of tannery sludge is recognized as a suitable method for its recycling before application into the soil. However, the effect of composted tannery sludge (CTS), in long-term, on soil microbial diversity should be evaluated to avoid environmental impact. This study evaluated the effect of CTS on bacterial diversity after 8 years of consecutive applications. CTS was applied at 0, 2.5, 5, 10, and 20 ton ha^{-1} and the bacterial diversity was evaluated at 75 days after CTS application at the 8th year. There was a trend in the decreasing of bacterial diversity after application of CTS. The amended soil, as compared with unamended soil, presented low bacterial similarity with the increase of CTS rates. Actinobacteria, Proteobacteria, and firmicutes were the most abundant phyla within the sites. Firmicutes and Proteobacteria were abundant in the amended and unamended soils, respectively. The correlation between bacterial diversity and soil chemical properties showed pH, Cr, and total organic C as drivers of bacterial diversity in CTS amended-soil. In conclusion, the application of CTS, in long-term, influences the soil bacterial diversity and selects different bacterial groups which may be adapted to high soil pH, Cr and organic matter content.

Support – CNPq

PESTICIDES MONITORING IN THE AGRICULTURAL SOILS IN THE CZECH REPUBLIC

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Basal Soil Monitoring (BSM) System is a programme for a long-term monitoring of agricultural soil quality in the Czech Republic. The BSM system was set up in 1992 and nowadays it comprises 214 monitoring plots. Monitoring plots are defined as rectangles 25x40 m, are defined by geography coordinates, landscape morphology and the nature of the soil and climate.

Monitoring of the pesticides was launched in 2014. Soil samples have been collecting from 40 monitoring plots. 72 active substances of the Plant protection products have been determined in each sample.

Approximately 100 active substances overall have been applied to the mentioned 40 plots each year. Azole compounds (e.g. tebuconazole, epoxiconazole) are the most frequently applied substances. The most frequently determined substances are azole substances again and the derivates of atrazine and terbuthylazine.

The derivates of atrazine (atrazin-2-hydroxy, atrazin-desisopro) were firstly analysed in soil samples in 2015 and in 2016 derivate of terbuthylazine (terbuthylazin-2-hydroxy) was firstly detected in our samples. All these substances were found in over half of the samples and justly attract our attention.

Metabolites of atrazine are monitored mainly because of absence of parent substance (atrazine) in the soil. The use of atrazine is banned in the European Union from 1 August 2005, regarding to possible harmful effect to human and animal health and to the findings of atrazine in drinking water. Then atrazine was replaced by terbuthylazine, a similar substance from the triazine group. Terbuthylazine is expected to have moderate to low mobility in soil. In soil it can degrade – its half-life in soil under field conditions ranges from 6.8 to 148 days.

The aim of this contribution is to present the content levels of mentioned pesticides and their degradation products in agriculture soils of the Czech Republic.

DIVERSIFICATION OF TROPICAL PASTURES; KEY TO C SEQUESTRATION AND IMPROVED SOIL HEALTH?

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In Latin America, livestock production contributes significantly to national development and food security and reduces the vulnerability of smallholders to income deprivation. However, inappropriate pasture management leads to low productivity and is an important driver of soil degradation and deforestation. Sustainable intensification is needed to increase economic benefits and resilience of pasture-based livestock systems and reduce the environmental footprint[1]. Diversifying improved grasses with legume forages can increase soil organic carbon (SOC), soil biodiversity and soil functioning (e.g. nutrient cycling, soil structure) and thus improve pasture productivity and carbon sequestration potential. However, quantitative evidence from tropical pastures is scarce. Our aims are:

i. to quantify effects of pasture diversification, including legumes, on SOC stocks and pools (Total SOC, POXC and aggregate-associated C)
ii. to assess effects of pasture diversification on soil biological and physical parameters (macrofauna, AMF root colonization, compaction, aggregation)
iii. to understand the relations between biological and physical parameters, SOC pools, and pasture productivity.

A trial was established in Palmira, SW-Colombia in 2014. Three treatments were randomly assigned to three blocks: T1-Brachiaria monoculture; T2-Bracchiaria intercropped with the herbaceous legume *Canavalia brasiliensis*; and T3-Bracchiaria intercropped with *C. brasiliensis* and strips of the legume tree *Leucaena diversifolia*. Grazing was rotated across blocks. Soil data were collected in 2014 and 2016-17 along a transect with increasing distance from the trees in T3. Results show that pasture productivity increased with pasture diversification. Highest C stocks (1m) were found in T3, in the tree rows. Forthcoming data demonstrate and quantify trade-offs and synergies associated with different models of pasture diversification, and may clarify soil-plant interactions that explain diversity/legume-induced changes in SOC cycling[2].

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COMPOSITION OF MICROBIAL COMMUNITY AT BIODEGRADATION OF DIFFERENT PLANT LITTER

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Research objective was a characterization of microbial community of plant litter at their degradation on the chernozem' soil. The method of microbial diagnostic based on gas chromatography – mass spectrometry of fatty acids, hydroxy acids and fatty aldehydes – was used for the study of the soil microbial community. Dry litter of leaves (1, the Quércus sample) and grasses (2, the Stipa sample) was placed with the soil in lizimeter bags with 4 kg of chernozem and was left composting for four months. It was shown that a microbial complex of initial litter (1) and (2) did not differ in the total bacterial content. After a composting, the amount of bacteria in (1) increased by 44% whereas amount of bacteria in (2) did not change. The main increase in sample (1) was due to actinobacteria Mycobacteriumsp. and Rhodococcus equi, which increased (15-fold), Arthrobacter globiformis (7-fold) and Corynebacterium sp. (5-fold).The amount of anaerobic species also increased: Desulfovibrio sp. (7-fold) and Eubacteria lentum (11-fold).These anaerobic species were increased in sample (2) as well, but to a lesser extent (4- and 6-fold, respectively). Biomass of microscopic fungi was more increased in (2) by 75%, and in (1) by 65%. Thus, the main contribution in a composting of sample (2) was due to microscopic fungi, whereas in (1) actinobacteria and microscopic fungi caused it. These species of microorganisms possess powerful hydrolytic properties; however, litter decomposition leads to different organic substances in the soil. Microscopic fungi can carry out a full mineralization reducing Corg of (2), and metabolites of microbial complex (1) producing various organic acids and biologically active substances.

SPRINGTAILS GROUPING IN POST MINING SITES CHARACTERIZATION

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Springtail grouping based on their niche speciation has been used for describing the collembolan communities relations with the area of sampling, bringing forward distinct feeding patterns based on groups morphological distinctions. In order to understand the importance of site age (sites of 10, 18, 28, and 55 years old), patch types and plant functional traits in different groups of springtails (i.e. epedaphics, hemedaphics, and euedaphics), a set of samplings have been done in a post-mining site located in Sokolov, Western Czechia. Sampling included three patch types (bare, grassy and woody). Analysis of variance and correlation analysis indicated that patch types, as visual assessment of vegetation coverage, were more important in explaining the presence of different springtail groups. Additionally, hemidaphic and euedaphics had shown almost a similar preference in the studies sites, being lower in sites with bare ground and age of 10, 18 years old. It is appears form our results, and is in line with other studies, that euedaphic springtails are less dependent on the vegetation though they were found more correlated to woody sites of 55 years old. Since passive migration is reported to be the primary source of the arrival of mesofauna in post-mining sites, it is reasonable to expect that presence of vegetation more than the kind of vegetation can play a role in the springtail's survival and eventually a successful colonization of the exposed spoil material.

LEACHING RISK OF MICROPLASTICS BY PREFERENTIAL FLOW IN BIOGENIC TUNNELS (EARTHWORM BURROWS)

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Microplastics (MP) are plastic debris smaller than 5 mm (Sutherland et al., 2010). MP research has mainly focused on aquatic ecosystems where MP has frequently detected but the potential risks of MPs in terrestrial ecosystems are not clear so far (Rillig 2012). Huerta (2016) showed that MP in soil surface litter could be ingested by earthworm and transported into burrows, which could increase the risk of MP leaching in groundwater. In this present study, we focus on assessing the MP leaching risks in soil with and without biogenic tunnels made by earthworms (Lumbricus terrestris). A laboratory experiment was conducted to measure the MP residues (Light Polyethylene) in soil columns with and without earthworm burrows and leachate. Four treatments and eight replicates of each treatment were designed: (1) T1, sandy soil and MP, (2) T2, sandy soil and MP mixed with dry litter on surface, (3) T3, sandy soil, dry litter on surface with two adult earthworms in each column, (4) T4, sandy soil, MPs with litter and two adult earthworms in each column. This experiment has started recently, and we will present the first results.

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Theme 6

Food security - Posters

ORGANOCHLORINE PESTICIDES RESIDUES IN SOIL, VEGETABLE AND MILK IN HORTICULTURE REGIONS OF NORTH EAST BANGLADESH

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Organochlorine pesticides (OCPs) are banned from application in agricultural land since decades. However, different studies show that they are still present in agricultural soils due to their high persistence.

We studied the occurence of OCPs residues (ΣDDTs, ΣHCHs, ΣAldrines, ΣEndosulfans, ΣHeptachlors, ΣChlordanes, Chlordecone and Mirex) in soils and their bioaccumulation in vegetables and milk in horticultural production regions, Bangladesh. Therefore we collected vegetable, soil and milk samples from 57 fields of two intensively managed vegetable growing areas of Bangladesh and analyzed 23 OCPs, to provide the extensive information of historical occurence and distribution patterns of these compounds in this area.

We detected OCPs in 22% of all vegetables, 41% soil and 7% milk samples. ΣDDTs in soil ranged from 6-68 ppb, ΣHCHs from 11-150 ppb, ΣAldrines from 3-25 ppb, ΣEndosulfans from 3-78 ppb, ΣHeptachlors from 7-55 ppb, ΣChlordanes from 4-50 ppb, Chlordecone from 11-21 ppb and Mirex from 3-22 ppb, partly exceeding the Dutch threshold values for single residues of 10 ppb (EU pesticides database). International threshold values do not exist. In 41% positive soil samples we detected multipe residues (1-23 OCPs).

In vegetables only ΣAldrines and ΣHCHs were detected ranging from 3-78 ppb and 3-36 ppb, partly exceeding the benchmark of 10 ppb (EU pesticides database) for food safety. Highest content of ΣAldrines were detected in cucumbers, highest ΣHCHs content in sponge gourds. The bioaccumulation factors from soil to vegetable of ΣAldrines and ΣHCHs are 3.1 and 4.1. In 21% positive vegetable samples we detected multipe residues (1-23 OCPs).

Only ΣDDTs was detected in milk ranging from 3.00-4.00 ppb, not exceeding the benchmark of 10 ppb (EU pesticides database) for food safety.

We conclude that vegetable consumption, specially consumption of cucumber and sponge gourd cause human health risk. The occurence of multiple residues in soils may cause environmental risk.

ASSESSMENT OF A PROTOTYPE DECISION SUPPORT TOOL FOR NUTRIENT MANAGEMENT WITHIN THE FRAMEWORK OF FUNCTIONAL LAND MANAGEMENT AT COMMUNITY LEVEL WITHIN NORTHERN ETHIOPIA

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Mismanagement has exposed Ethiopian highlands to extremely depleted soil organic matter and nutrient-mining. Due to climatic shocks and knowledge gaps on nutrient management planning, inter alia, farmers hesitate to adopt recommendations that increase productivity. Although farmers are getting nutrient advice based on the nutrient requirements of the nearest-grid-sample from 10*10km grid-based soil survey, the huge diversity in soil types/properties results in reduced nutrient-use-efficiency. To narrow this gap, AFER+ project has been launched to develop a prototype decision-support-tool (DST) to smallholder farmers, for crop and soil-specific nutrient advice. Its joint objectives are: using the *diagnostic approach* to categorize soil types to supply a suite of plant nutrients; enhancing nutrient-use-efficiency; and assessing soil functionality at community level using the *Functional Land Management* (FLM) framework.

FLM is a policy assessment tool to incentivise land management practices by matching the supply-of and demand-for soil functions (primary productivity, nutrient cycling, carbon sequestration, water regulation and habitat for biodiversity), at spatial scales. Its core concept, *optimization of multi-functionality of soils to make the most of our land*, will be assessed via integration of soil science and participatory research within the community. Besides geo-climate, soil functionality depends on anthropogenic interventions (land-use and soil management) affecting soil functions simultaneously leading to synergistic or antagonistic interactions.

The specific objectives for this component of AFER+ are assessment and quantification of the demand-for and the supply-of soil services, their interactions and community-based approaches to implement the nutrient-DST and for developing a roadmap model for FLM.

We will interview 300 households in Endemehony, Laelay-maychew and Raya-kobo districts and develop proxy-indicators and scenario-maps. We will explore how nutrient cycling is largely defined by local land-use and soil conditions. Assessment of policy tools to maximize synergies and minimize trade-offs, ex-ante and ex-post evaluations will be conducted on the resulting DST for adoption and sustainability.

ENHANCEMENT OF PHOSPHATE ACQUISITION AND DELIVERY TO PLANTS USING THE CYANOBACTERIUM NOSTOC PUNCTIFORME

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Microorganisms are integral to the soil phosphorus cycle and as such play an important role in mediating the availability of P to plants. Understanding the microbial contribution to plant P nutrition and the opportunities for manipulating specific microorganisms to enhance P availability in soil is therefore of considerable interest. We propose that the cyanobacterium *Nostoc punctiforme* plays a significant role in enhancing plant growth by enhancing phosphate availability. Further to this, its robust nature and competence to form symbiosis with a broad range of hosts, which potentially includes wheat and canola as well as rice, makes it a potentially more attractive option for commercial development over other bacterial species. The role *N. punctiforme* potentially plays in enhancing phosphate bioavailability to its host during symbiosis are possibly through the two following pathways: (i) phosphate is transferred through *N. punctiforme* into the host, (ii) phosphate is chelated from the silicates in soil where it is bound by extracellularly excreted bioactive enzymes. To determine the mechanisms facilitating phosphate trafficking by *N. punctiforme* to its hosts, we have produced mutants that are deficient of an imperative phosphate transport system component (PstB-) and mutants over-expressing the PstB system component, potentially resulting in respective phosphate deficient and over-accumulating phenotypes. The genetically manipulated N. punctiforme phenotypes are to be investigated for their capacity to alter cellular phosphate levels in *Geosiphon pyriformis*.

APPLYING A DIAGNOSTIC APPROACH TO SOIL CLASSIFICATION AND TO EXPLAIN AND MANAGE NUTRIENT CYCLING IN ETHIOPIAN SOILS OF NORTHERN AMHARA AND TIGRAY REGIONS

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Ethiopia has a wide range of topographic, geologic and climatic features. Diverse in biophysical and climatic setting has enabled the country to grow many different crop cultivars. Agriculture is the mainstay of Ethiopian economy. However, it is characterised by low production and productivity per unit area. The available soil management system is not based on inherent soil characteristics and their nutrient supply capacity. This is mainly because of lack of simple and affordable methods to characterise and classify soil from a nutrient supply capacity perspective. Poor soil management practices and low application of organic and inorganic fertilizers result in a farming system that depends on mining the inherent soil nutrients without consideration of required inputs for increased production capacity. Therefore, this research will describe, characterise and classify a range of agricultural soils to identify the key diagnostic features (horizon, properties and materials) that govern the nutrient cycling and provision capacity of contrasting soils of Northern Ethiopia. Profile description and characterisation of soil reference groups will be examined according to FAO Guidelines for soil description and the classification will be performed using World Reference Base (WRB) 2014 descriptors. This information will provide a basis for the diagnostic characterisation of the soils in three Ethiopian catchments representing; Teff, Sorghum and Wheat production systems. Utilising the diagnostic approach, the soil will be ranked and numerically expressed, based on the performance of diagnostic horizons, properties and materials to perform the soil functions. From this research the differences between the agricultural soils to perform the functions associated with nutrient cycling and supply will be identified. Finally, the study will contribute to the development of decision support tool for on-farm nutrient management as advisory tool for Ethiopian soils.

AGROFORESTRY-BASED RESTORATION FOR ENHANCED RESILIENCE OF AGRICULTURAL PRODUCTION IN THE DRY CORRIDOR OF CENTRAL AMERICA

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Rural communities in the Dry Corridor of Central America are highly vulnerable to soil and land degradation and climate change. Smallholder farmers traditionally produce grain crops on steep hillsides through slash-and-burn agriculture, increasingly combined with small-scale cattle farming. Only 3% of the original forest cover remains. Through participatory design and adaptation of agroforestry-based systems we aim to restore degraded land and ecosystems services, while enhancing agroecosystem productivity, profitability and resilience. Between 2008 and 2013 a platform of 25 on-farm experiments, across three different sites in the Dry Corridor of Nicaragua, was established. The platform served different objectives: (i) participatory adaptation of agroforestry systems; (ii) research to understand and quantify the impacts of agroforestry-based interventions on ecosystem services, including crop production, and farmer revenues (iii) knowledge sharing and training of farmers and technicians. Agroforestry systems included Quesungual a maize-bean system intercropped with trees and established through selective clearing and pruning of regenerated trees. Different land use systems were established/selected on the participating farms: Traditional slash-and-burn maize-bean system (TCS), Quesungual Agroforestry (AFS) and Secondary forest (SF). Crop and forage production, soil fertility, soil erosion, C sequestration and biodiversity were monitored from 2013 to 2016. Results confirm that AFS can improve tree diversity conservation and carbon storage, while maintaining (maize) and increasing (bean) production. Collection of detailed soil, plant, microclimate and meteorological data allowed for the modelling of tree-crop interactions and land use scenarios to further evaluate impacts of Quesungual on ecosystem services. Results demonstrate that AFS contributes to land restoration and ecosystems services, without losing crop production. However, further improvements in the design of agroforestry systems or farm resource allocation are needed to further improve production levels and security. To that end, a synthesis of key lessons from the project and reflections on future directions will be presented.

MUSHROOM HEALTH: A SYSTEMS STUDY

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Mushroom cultivation is done on a substrate of compost over which a layer of casing soil is applied. The casing soil comprises of peat, limestone and chalk, and is rich in organic matter. Fruiting of mushroom bodies relies heavily on the dynamic interactions between *Agaricus bisporus* and other microbes present in this casing soil. However, various pathogens introduced from the casing soil cause diseased crop with severe economic losses.

This study aims to identify key factors determining bacterial blotch and fungal wet bubble outbreaks in mushroom cultivation. It aims to identify key indicators for disease suppressive characteristics in different casing soils against these pathogens.

Taqman PCRs were developed as quantitative detection methods for various blotch pathogens. Metagenomic analysis of different casing soils was performed using amplicon targeted sequencing of the 16S and ITS regions. Mushrooms cultivation bioassay were performed to check blotch prevalence under varied biotic and abiotic conditions.

P. gingeri is a more aggressive pathogen for bacterial blotch than *P. tolaasii*. Their infection and population dynamics differ significantly in casing soils. Higher microbial biodiversity in casing soil seems to lead to lower native blotch prevalence. Microbiome analysis show that physio-chemical properties of peat, and the other raw materials used in preparation of casing soils, affect its inherent microflora.

PLANT PARASITIC NEMATODE ASSEMBLAGES ASSOCIATED WITH POTATO IN TETRITSKARO (EASTERN GEORGIA)

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Potato is one of the most important staple food crops consumed in Georgia. The aim of this study was to determine the prevalence and diversity of PPN in Eastern Georgia potato fields. 2000 soil sub-samples and 50 infested tubers were collected from five potato growing sites in Tetritskaro counties. Extraction of PPN from soil and root sample was done using modified extraction tray method and modified maceration extraction technique respectively. Extracted nematodes were enumerated, identified to species level and their frequencies of occurrence and abundance determined. The material was collected in full vegetation period. The soil samples were also tested before planting and after harvest

During the research process in the studied ecosystems there were registered 109 forms of Free-living and Phyto-parasitic nematodes, from which 65 forms are determined as species, as familie 3, as genus 40. The registered nematodes belong to 8 orders 34 families and 56 genera.

Plant-parasitic nematodes from 10 genera, including economically important pests were detected in soil and (or) potato root samples. These genera were *Pratylenchus, Helicotylenchus, Rhotylenchus, Xiphinema, Ditylenchus, Paratylenchus*, Tylenchorinchus, Aphelenchus, Aphelenchoides, and Paraphelenchus. Ditylenchus destructor was the most prevalent and abundant plant-parasitic nematode in studied ecosystems. In soil samples Ditylenchus was found at frequencies of 38%, 32%, 27% and 5% respectively.

The study of trophyc structure of nematodes showed that in fauna prevail predatory species, namely the reprezentatives of order Mononchida and gorylaimida that inhabit the soils of almost all natural and agroecosistems.

Based on results of research it is possible to conclude, that increase in number of a pathogen in the soil is a result of invasive sowing material. It is necessary to give more attention to agrotechnical actions, reducing danger of infecting the soil. Studying of distribution and monitoring of PPN in Eastern Georgia continues.

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